FRESHWATER BIODIVERSITY:
Report of a workshop on the Conservation of Freshwater Biodiversity in Latin America and the Caribbean held in Santa Cruz, Bolivia, September 27-30, 1998

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Preface

FRESHWATER ECOSYSTEMS in Latin America and the Caribbean (LA/C) harbor extra-ordinarily rich and unique biodiversity. There are also severe threats to freshwater biodiversity throughout LA/C, including widespread damming and extraction of water, overfishing, contamination, and exotic species; all are contributing to the loss of natural habitats and species over vast areas. In many parts of LA/C, fresh-water ecosystems are even more threatened than are terrestrial ecosystems. Despite this, conservation of freshwater biodiversity has been seriously underrepresented in protected area systems and has received insufficient conservation donor funding. Entire freshwater ecosystems are now at risk of being eliminated.

This analysis is a first attempt to characterize, map, and evaluate the priority for conservation action in large areas of freshwater biodiversity in the LA/C region. The ecoregional approach adopted by this study can help conservation planners address large-scale and long-term issues that will ultimately determine the success of conservation efforts. Because the conservation target of an ecoregional approach is the entire biota, from species to higher taxa to whole communities and ecosystems, it is more likely that the full range of distinctive biodiversity will be represented when an ecoregion is conserved. This report assesses the relative importance of biodiversity at varying biogeographic scales, from local to global. The importance of conserving ecological and evolutionary phenomena and processes that maintain and create biodiversity is also emphasized in this report.

While the data for many ecoregions described herein are limited or still unsynthesized, this analysis can nevertheless provide a framework for linking the timing of conservation investments with principles of conservation biology and aqua/landscape ecology. We hope that this framework and analysis will catalyze future work by scientists and conservationists concerned with setting conservation priorities.

We expect that these results will help conservation donors better understand which ecoregions in LA/C harbor the most important freshwater biotas and where there is greatest urgency for action. Bilateral and multilateral donors, international organizations, and governments can use the results of this report to argue for increased resources to protect the most distinctive, representative, and threatened areas of freshwater biodiversity in LA/C. It is our hope that, by recognizing the extraordinary freshwater biodiversity of LA/C and its threatened status, future conservation investments will shift toward a more balanced portfolio of terrestrial, marine, and freshwater projects.

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Executive Summary

Background

THE LATIN AMERICAN and Caribbean region supports the most diverse freshwater biodiversity on Earth. The Amazon Basin alone is estimated to contain between 3,000 and 9,000 species of fish, and the entire LA/C area harbors over one quarter of the world's fish species. Many species are restricted to limited geographic areas. For example, some snails and fish are limited to a single small pool in exceptional cases, illustrating the complexity of the freshwater habitats. Unique and unusual habitats occur through-out the region, including extraordinarily productive flooded forests along the larger tropical rivers, high-altitude lakes and páramo wetlands, limestone habitats of Mexico and Central America, and isolated basins of the northern deserts. Remarkable ecological phenomena include tremendous migrations of fish covering thousands of miles of the Amazon's rivers and seasonal movements between the rivers and flooded forests. In these habitats, one finds a variety of fruit-eating fish that serve as important seed dispersal agents. The deep channels of the Amazon are inhabited by blind or nearly blind fish, many with heightened electric senses and unusual diets, such as specialists that feed on other fishes' tails. The incredible radiation of species in the Chihuahuan Desert springs, high-altitude Andean and Mexican lakes, and Amazonian and Orinoco basin streams are just a few of the region's outstanding evolutionary phenomena.

Despite this wealth of freshwater habitats and phenomena, most people equate the region's biodiversity mainly with the terrestrial species of the tropical rain forests. Yet, the waters of the tropical Americas harbor a vertebrate fauna richer than any found in the adjacent forests, and the poorly-known aquatic invertebrates and plants are likely to be highly diverse as well. In addition to their biodiversity value, freshwater ecosystems are tremendously important economically. Conservation of this resource is essential as so much of the human population relies on it, not only for drinking water, but also for transportation, food production, energy, industry, waste disposal, recreation, and aesthetic value.

It is unfortunate, then, that fresh-water biodiversity around the world is even more threatened than terrestrial biodiversity. Despite the extraordinary richness, uniqueness, and economic importance of freshwater ecosystems, particularly those in LA/C, freshwater ecosystems are highly underrepresented in both networks of protected areas and in receiving conservation donor funding.

The threats to freshwater biodiversity are so severe and present conservation attention and resources are so limited that, to conserve these unique ecosystems and communities, we must promote a wider recognition of their biodiversity value within the context of a global conservation strategy and determine the most distinctive and threatened biogeographic units needing immediate support.

In 1994, the Biodiversity Support Program (BSP), a consortium of World Wildlife Fund, The Nature Conservancy, and World Resources Institute, funded by the U.S. Agency for International Development (USAID), organized a workshop where biodiversity conservation priorities for terrestrial systems of LA/C were identified (Biodiversity Support Program et al. 1995). Participants at that workshop recognized the urgent need to adapt this priority-setting framework to aquatic freshwater and marine systems. Responding to this need, USAID provided BSP with funding to carry out priority-setting exercises for freshwater and marine habitats.

BSP commissioned World Wildlife Fund and Wetlands International to undertake a conservation assessment of freshwater ecoregions of LA/C as a first step in prioritizing efforts to save them. Regional priorities for the conservation of freshwater biodiversity were assessed at a workshop in Santa Cruz, Bolivia in the fall of 1995; the results of that assessment are presented in this report. Workshop participants included recognized experts in the field of freshwater biodiversity from the LA/C region, as well as from the United States (see Appendix H).

A complementary marine analysis for LA/C, organized by The Nature Conservancy, with funding from BSP, was conducted in September 1996. The methodology and identification of preliminary priorities for coastal and marine habitats are available in a separate report (Sullivan and Bustamante 1999).

A parallel analysis of the conservation status of wetlands of South America was conducted at the 1995 Santa Cruz workshop in collaboration with Wetlands International. The results of detailed regional analyses by wetland specialists were synthesized at the workshop and are available in a report from Wetlands International (Canevari et al. 1998). The Wetlands International portion of the work received support from the United Nations Environment Programme (UNEP), USAID, and the Moriah Foundation.

Taking an Ecoregion-based Approach

The distribution of species and communities rarely follows state or provincial boundaries. For example, Venezuela contains several ecoregions (which we define as relatively large areas of water and land that share a large majority of species, dynamics, and environmental conditions) that encompass coastal rivers, large river deltas, flooded savannas, and large river headwaters. Dividing Venezuela into several ecoregions offers a superior framework for representing all of its unique habitats and species assemblages in conservation programs, avoiding duplication of effort across political jurisdictions, capturing the geographic area over which ecological processes operate, and defining the arena for future restoration programs. Lumping all of Venezuela's ecoregions into one political unit, while simultaneously truncating their full extent in neighboring countries, runs the risk of overlooking important features and conservation needs specific to each ecoregion.

An ecoregion-based approach targets the entire biota, from species to higher taxa to communities, rather than just a few well-known larger or charismatic species. In our methodology, the relative rarity of biodiversity features is assessed at varying biogeographic scales, from local to global. This approach also emphasizes the importance of conserving ecological and evolutionary phenomena and processes that maintain and create biodiversity. By looking at the bigger picture through ecoregion-scale analyses, it becomes easier to identify the places where there is a global responsibility to protect and restore habitats that are unique to the world, as well as reveal gaps in current and proposed conservation networks and strategies.

Taking the ecoregion as our unit of analysis, this study quantifies the biological diversity of freshwater ecoregions of South America, Central America, the Caribbean, and Mexico. A separate analysis of North American freshwater ecoregions (again including Mexico) complements this study (Abell et al. In press). Mexican freshwater ecoregions are being further evaluated by CONABIO (Comisión Nacional para el Conocimiento y Uso de la Biodiversidad), the biodiversity agency of Mexico (Arriaga et al. 1998). Recent analyses of major watersheds and freshwater hotspots of the world should also be consulted (Revenga et al. 1998; WCMC, In prep.).

Methods and Findings

Forty-two freshwater ecoregion complexes were identified for LA/C, within which 117 ecoregions were delineated (see Table 1 and Fig. A-1). Ecoregions were classified according to their major habitat type, ranging from large rivers to closed basins in dry regions.

Ecoregions were assessed using two primary discriminators:

Biological Distinctiveness

This was assessed through an analysis of species richness, endemism, ecosystem diversity, and special considerations (rarity of major habitat type and unusual ecological or evolutionary phenomena), and point scores were assigned for each characteristic. Based on these scores, ecoregions were designated as globally outstanding, regionally outstanding, regionally important, or locally important.

Conservation Status

This is an estimate of the current and future ability of an ecoregion to maintain viable species populations, sustain ecological processes, and be responsive to short- and long-term change. Determinants of an ecoregion's conservation status include habitat loss, water quality, and hydrographic integrity. Each ecoregion's status was classified as critical, endangered, vulnerable, relatively stable, or relatively intact.

An assessment of biological distinctiveness at different biogeographic scales identified 11 ecoregions (9%) as globally outstanding, 51 (44%) as regionally outstanding, 30 (26%) as regionally important, and 25 (21%) as locally important. Some regions with globally outstanding biodiversity include the western arc of the Amazon River basin, the Southern Orinoco, the Río Negro, the Chihuahuan Desert, high-elevation lakes of central Mexico, the Llanos, the Guiana Watershed, and the varzea flooded forests of the Amazon.

An assessment of conservation status identified 9 (8%) ecoregions as critical, 43 (37%) as endangered, 49 (42%) as vulnerable, 13 (10%) as relatively stable, and 3 (3%) as relatively intact. Overall, more than 85% of the freshwater ecoregions of LA/C were assessed as critical, endangered, or vulnerable. When compared with 60% of the terrestrial ecoregions assessed in these same categories (Dinerstein et al. 1995), it becomes evident that freshwater ecosystems have been substantially more impacted than have terrestrial ones. Some critical ecoregions are found in the Caribbean lowlands and intermontane valleys of Colombia, the Maracaibo Basin, Lake Poopó, the delta of the Colorado River, coastal Sinaloa, Lerma and Lake Patzcuaro of central Mexico, the Atacama/Sechura deserts, the Parano-Platense delta, and northern portions of the Mediterranean region of Chile.

Integrating biological distinctiveness and conservation status provided a framework for priority-setting. Those ecoregions that were given a priority status of 1 (highest priority for conservation action) had biological distinctiveness that was considered globally outstanding and a threat ranking that was either endangered or vulnerable. The following 10 ecoregions received this ranking (see Fig. A-5):

Table 1. Freshwater Ecoregions by Ecoregion Complex, Showing Major Habitat Type, Biological Distinctiveness, Conservation Status, and Priority Status

Ecoregion	Major Habitat Type	Biological Distinctiveness	Conservation Status	Priority Status
Baja California Complex				
1. Baja California	5	LI	V	4
Colorado River Complex				
2. Colorado Delta	2	RO	C	3
3. Sonoran	5	LI	E	3
Sinaloan Coastal Complex				
4. Sinaloan Coastal	4	RI	C	3
Rio Bravo Complex				
5. Rio Bravo	1	GO	E	1
6. Pecos	5	RO	E	2
7. Guzman	6	RI	E	3
8. Mapimi	6	RI	E	3
9. Cuatro Cienegas	6	GO	V	1
10. Llanos El Salado	6	RO	E	2
11. Conchos	5	RO	E	2
12. Lower Rio Bravo	1	RO	E	2
13. Rio San Juan	5	RO	E	2
14. Rio Salado	5	RI	E	3
Lerma/Santiago Complex				
15. Santiago	4	RI	E	3
16. Chapala	5	GO	E	1
17. Lerma	6	RO	C	3
18. Rio Verde Headwaters	5	RO	E	2
19. Manantlan/Ameca	4	RI	V	3
Rio Panuco Complex				
20. Rio Panuco	4	RO	E	2
Balsas Complex				
21. Balsas	4	RI	E	3
Pacific Central Complex				
22. Tehuantepec	4	RI	E	3
Atlantic Central Complex				
23. Southern Veracruz	4	RO	E	2
24. Belizean Lowlands	4	RO	V	2
25. Central American Caribbean Lowlands	4	RO	RS	3
26. Talamancan Highlands	3	LI	V	4
27. Catemaco	9	RO	V	2
30. Yucatan	4	RO	V	2
31. Guatemalan Highlands	9	RO	V	2
32. Central American Karst Highlands	4	RO	V	2
33. Honduran/Nicaraguan Highlands	4	RI	E	3
34. Lake Nicaragua	9	RO	E	2
Isthmus Atlantic Complex				
35. Isthmus Atlantic	4	RI	RS	3
Isthmus Pacific Complex				
36. Isthmus Pacific	4	RI	E	3
Bahama Archipelago Complex				
37. Bahamas	4	RI	RS	3
Western Insular Caribbean Complex				
38. Cuba	4	RO	V	2
39. Hispaniola	4	RO	E	2
40. Jamaica	4	RI	E	3
41. Cayman Islands	4	LI	V	4
42. Florida Keys	4	LI	E	3
Eastern Insular Caribbean Complex				
43. Puerto Rico and Virgin Islands	4	RO	V	2
44. Windward and Leeward Islands	4	LI	E	3
Choco Complex				
45. Choco	4	RO	V	2
South American Caribbean Complex				
46. Magdalena	4	LI	C	3
47. Momposina Depression-Rio Cesar	4	RI	RS	3
48. Cienega Grande de Santa Marta	4	RI	E	3
49. Guajira Desert	5	RI	V	3
50. Maracaibo Basin	4	RO	C	3
High Andean Complex				
51. Paramos	8	RO	RS	3
52. Peru High Andean Complex	3	RI	V	3
53. Bolivian High Andean Complex	3	LI	V	4
54. Arid Puna	6	RO	V	2
55. Subandean Pampas	6	RO	V	2
56. South Andean Yungas	3	RO	V	2
Inter-Andean Dry Valleys Complex				

Ecoregion	Major Habitat Type	Biological Distinctiveness	Conservation Status	Priority Status
28. Coatzacoalcos	4	RO	E	2
29. Grijalva-Usumacinta	4	RO	V	2
Inter-Andean Dry Valleys Complex				
57. Inter-Andean Dry Valleys	3	LI	V	4

Major Habitat Type	Biological Distinctiveness	Conservation Status	Priority Status
1 = Large Rivers	Globally Outstanding (GO)	Critical (C)	1 = Highest Priority for Conservation at Regional Scale
2 = Large River Deltas	Regionally Outstanding (RO)	Endangered (E)	2 = High Priority for Conservation at Regional Scale
3 = Montane Rivers and Streams	Regionally Important (RI)	Vulnerable (V)	3 = Priority for Conservation at Regional Scale
4 = Wet-Region Rivers and Streams	Locally Important (LI)	Relatively Stable (RS)	4 = Important at Subregional and Local Scales
5 = Xeric-Region Rivers and Streams		Relatively Intact (RI)	
6 = Xeric-Region Endorheic (closed) Basins			
7 = Flooded Grasslands and Savannas			
8 = Cold Streams, Bogs, Swamps, and Mires			
9 = Large Lakes			

Table 1. (*Continued*)

Ecoregion	Major Habitat Type	Biological Distinctiveness	Conservation Status	Priority Status
North Andean Montane Complex				
58. North Andean Montane	3	RI	E	3
59. Humid Andean Yungas	3	RI	V	3
60. Chuquisaca and Tarija Yungas	3	LI	E	3
61. Salta and Tucuman Yungas	3	LI	V	4
62. Sierra de Cordoba	3	LI	V	4
Puyango-Tumbes Complex				
63. Puyango-Tumbes	4	RO	V	2
Atacama/Sechura Complex				
64. Atacama/Sechura Deserts	5	LI	C	3
Pacific Coastal Desert Complex				
65. Pacific Coastal Deserts	5	RI	E	3
Lake Titicaca/Poopo Complex				
66. Lake Titicaca	9	GO	V	1
67. Lake Poopo	9	RI	C	3
Galapagos Complex				
68. Galapagos	5	LI	RS	4
Mediterranean Chile Complex				
69. North Mediterranean Chile	5	RO	C	3
70. South Mediterranean Chile	5	RO	E	2
Juan Fernandez Islands Complex				
71. Juan Fernandez Islands	4	RI	E	3
Southern Chile Complex				
72. Valdivian	4	RO	V	2
73. Chiloe Island	4	RO	E	2
74. Chonos Archipelago	4	RI	RS	3
75. Magallanes/Ultima Esperanza	8	RI	RI	4
Subantarctic Complex				
76. Subantarctic	8	LI	RI	4
Venezuelan Coast/Trinidad Complex				
77. Venezuelan Coast/Trinidad	4	LI	E	3
86. Rio Negro	1	GO	V	1
87. Upper Amazon Piedmont	1	GO	V	1
88. Western Amazon Lowlands	1	RO	RI	3
89. Central Brazilian Shield Tributaries	1	RO	V	2
90. Tocantins-Araguaia	1	RO	V	2
Northeast Atlantic Complex				
91. Maranhao	4	LI	E	3
Mata-Atlantica Complex				
92. Northeast Mata-Atlantica	5	RO	E	2
93. East Mata-Atlantica	4	RO	E	2
94. Southeast Mata-Atlantica	4	RO	E	2
Sao Francisco Complex				
95. Caatinga	5	RO	E	2
96. Cerrado	4	RO	E	2
Upper Parana Complex				
97. Upper Parana	1	RO	E	2
Beni Complex				
98. Beni	7	RI	V	3
Paraguay-Parana Complex				
99. Pantanal	7	GO	V	1
100. Lower Parana	1	RO	E	2
Southern Atlantic Complex				
101. Jacui Highlands	4	LI	E	3
102. Lagoa dos Patos Coastal Plain	4	LI	E	3
Chaco Complex				
103. Chaco	4	RI	V	3
Pampas Complex				
104. Parano-Platense Basin	2	RI	C	3
105. Rio Salado and Arroyo Vallimanca Basin	7	RI	V	3
106. Northwest Pampas Basins	6	LI	V	4
107. Pampas Coastal Plains	7	LI	V	4

o Río Bravo (Ecoregion No. 5). The freshwater fauna of the Río Bravo (Rio Grande) ecoregion is likely the richest of any arid-region river system in the world. Many endemic species are found here as well. Extensive diversion of water, channelization, loss of riparian habitat, pollution, and alien species threaten the unusual biota.

o Cuatro Ciénegas (Ecoregion No. 9). This basin in the Chihuahuan Desert harbors a complex network of springs and pools that support a globally outstanding assemblage of endemic fish, snails, reptiles, and invertebrates. Cuatro Ciénegas is referred to as "the freshwater Galápagos of the Americas" because fish and snails have undergone spectacular evolutionary radiations here. Water mismanagement threatens many of the pools and springs, and alien species are an increasing threat. This unique basin is being considered for more formal protection.

o Chapala (Ecoregion No. 16). This lake of Mexico's highlands has an unusually rich endemic fish and amphibian fauna. Water diversion and urban and agricultural pollutants are major threats.

o Lake Titicaca (Ecoregion No. 66). The unusual evolutionary radiations of fish and invertebrates in Lake Titicaca, a large high-altitude lake of the central Andes, represent a globally rare phenomenon. Introduced species and pollution threaten this unusual assemblage.

o Llanos (Ecoregion No. 78). Located in Venezuela and Colombia, this tropical wetland complex-one of the world's largest-supports a diverse fish fauna with many endemic species. Conversion of freshwater and wetland habitats for intensive agriculture and livestock continues to threaten the diverse fauna.

o Southern Orinoco (Ecoregion No. 81). This ecoregion supports arguably the richest freshwater biotas on the planet. Several unusual freshwater habitat types, such as white-sand flooded forests, occur here as well. Large dams and water diversions planned for several large tributaries spell disaster for this native freshwater ecosystem. Pollution and siltation from mining and deforestation, as well as hunting of sensitive larger vertebrates, pose other threats.

o Amazon Main Channel (Ecoregion No. 84). This channel contains the world's richest large river fauna. Many globally rare communities, such as assemblages of blind fish in deep channels, and such phenomena as seasonal migrations of many species into flooded forests occur here. Commercial fisheries may pose problems for some target species.

o Río Negro (Ecoregion No. 86). Along with the Southern Orinoco, this ecoregion supports some of the world's richest freshwater biotas. Several unusual freshwater habitat types, such as white-sand flooded forests, occur here. Large dams and water diversions are major threats. Other threats include pollution and siltation from mining and deforestation, as well as hunting of sensitive larger vertebrates.

o Upper Amazon Piedmont (Ecoregion No. 87). This region of the Amazon Basin is remarkable for a fauna that is globally diverse, displays unusual adaptations to dynamic environments, and has a high degree of local endemism. Growing threats to these biotas include toxins from mining and oil extraction, loss of surrounding forests that cause changes to water quality and sedimentation, and hunting of sensitive, larger freshwater species.

o Pantanal (Ecoregion No. 99). Like the Llanos, the Pantanal is one of the world's largest tropical wetland complexes, containing amazing concentrations of freshwater species and some of the last remaining populations of sensitive larger vertebrates, such as giant river otters. Major channelization schemes, if implemented, would drastically alter this extraordinary ecoregion.

The globally outstanding ecoregions described above (a priority status of 1) are either endangered or vulnerable and require immediate conservation intervention. Globally outstanding ecoregions that are relatively intact were not identified as highest priority at this juncture because of the urgency of more threatened ecoregions. There was agreement that ecoregions in this category are critically important to conserve, warrant constant vigilance against threats, and present situations where conservation efforts can be cost-effective.

Some of the ecoregions considered high priority for conservation action at a regional scale (a priority status of 2) are located elsewhere in the Chihuahuan region, the Petén, Chocó, Central Brazilian Shield, Guiana Watershed, and central Patagonia.

Globally and regionally outstanding ecoregions whose final conservation status was critical were ranked as being second or third priority, respectively, for conservation action. This was due, in part, to the extreme difficulty of restoring critical freshwater ecosystems because of the strong dynamic linkages throughout the entire ecoregion (i.e., the necessity of interventions at the scale of whole watersheds). In contrast, this combination of features was selected as highest priority in a previous WWF analysis of terrestrial ecoregions of LA/C (Dinerstein et al. 1995).

Because highest priority freshwater ecoregions do not coincide precisely with highest priority terrestrial ecoregions, as identified by Dinerstein et al. (1995), an overlap of terrestrial and freshwater ecoregions in this category helps identify significant conservation priorities at this hemispheric scale. Ecoregions particularly important from both terrestrial and freshwater perspectives include the western arc of the Amazon, the Southern Orinoco and Guayanan Highlands, Río Negro, the Atlantic region of Brazil, the Greater Antilles, and the Chihuahuan Desert.

Recommendations

Conservation donors can use this analysis, prepared by a diverse group of regional freshwater biodiversity experts, to better understand which regions in LA/C harbor the most important freshwater biotas and where there is the most urgent need for action. While this study does not analyze the most effective conservation action that can be taken in freshwater areas, it does highlight some of the most significant threats in the different regions. For example, in wet tropical environments, freshwater ecosystems are most threatened by the profusion of dams, loss of seasonally flooded forests and wetlands, and deforestation of surrounding watersheds. In more arid regions, some of the greatest threats are diversion of surface and ground waters, loss of riparian vegetation, and exotic species. Therefore, specific actions needed in priority areas must be identified through more detailed, ecoregion-scale analyses.

We recommend that USAID continue to play a leadership role within the donor community in using the results of these types of analyses to direct its own funding toward those ecoregions identified as highest priority for conservation action and toward areas not currently receiving sufficient conservation investment. In addition, we hope that USAID will encourage other donors to do the same. Finally, we urge donors to refer to this analysis as they move through the process of identifying their programmatic strengths and determining which will have the greatest impact on freshwater conservation.

Over the past few years, the production and application of logical and transparent geographic priority-setting frameworks have made great strides. We hope that this analysis for freshwater biodiversity in LA/C will also serve as a useful tool for conservationists and donors to allocate their scarce resources in the most effective way.

Chapter 1
Introduction

THE FRESHWATER BIODIVERSITY of LA/C is truly extraordinary. Biologists have often called South America the "bird continent," but it could also be appropriately referred to as the "fish continent." Nearly half of all described vertebrates are teleost fishes, and one quarter of these are estimated to occur in the Neotropics. More than 3,000 species of fish are thought to live in the Amazon Basin (Goulding 1985), site of the world's largest and most diverse freshwater ecosystems (Goulding, Smith, and Mahar 1996). The total number of Amazonian fish species may be as high as 9,000 (Conservation International 1997).

Amazon catfish and characoid fish, in particular, have diversified into a wide range of species with varied life histories and forms. Scientists have recently discovered an astounding diversity of fish species in the leaf litter and detritus of tributary rivers and streams in the Amazon and Orinoco basins (Chernoff 1995), as well as a whole fauna of blind, deepwater fish from the main Amazon River channel (Yoon 1997). A number of species normally associated with marine environments inhabit the larger rivers, including bull sharks, drums, manatee, and two species of dolphin. Giant river otters, anacondas, enormous catfish, and several species of caiman that once attained lengths of more than four meters, are some of the larger denizens of these enormous river systems. A great diversity of aquatic invertebrates and plants also occur throughout the Amazon. The La Plata-Paraná Basin of southern South America represents a third large river system with a rich fish fauna.

Within the Amazon and Orinoco basins, a wide diversity of freshwater habitats occurs, including large rivers (classified as "whitewater," "blackwater," and "clearwater," according to their source and water characteristics), floating meadows, seasonally flooded or varzea forests, swamp forests, cataracts, mangroves, white-sand or igapó flooded forests, small rivers and streams, and oxbow lakes. Although the Amazon and Orinoco river ecosystems are the dominant and widely recognized elements of Neotropical freshwater biodiversity, the LA/C region contains a diverse array of other freshwater habitats and communities. Vast, seasonally flooded savannas occur in the Llanos, Pantanal, Chaco, and Beni savannas, each endowed with a rich freshwater biota. Cold montane streams and cataracts occur in the High Andes, Amazonian Piedmont, and other mountainous regions.

Other distinct freshwater habitats include páramo bogs and wetlands; high-elevation freshwater and saline lakes of the Andes; wetlands and shallow lakes or lagunas of the Pampas and Patagonian steppes; large highland lakes of Central America and Mexico; cold temperate bogs, swamps, and mires of the Southern Cone; spring and cave biotas of the Chiapas and Oaxaca regions of Mexico and the Greater Antilles; fogdrip pools and streams of the Pacific deserts of Peru and Chile; and closed-basin (endorheic) springs, pools, and streams in the Chihuahuan Desert. Many regions support highly distinctive freshwater biotas with large numbers of endemic species. Some long-isolated regions, such as in the Greater Antilles, Southern Cone, and Chihuahuan Desert, contain species and higher taxa that represent ancient lineages. Overall, the freshwater biodiversity of LA/C is the richest on Earth, with highly distinctive habitat types, communities, and species.

Recognizing and Addressing the Problem

Throughout the world, conservation of freshwater biodiversity has been seriously neglected, and whole freshwater ecosystems and biotas are threatened with extinction on a grand scale (Allan and Flecker 1993; Heywood and Watson 1995; Abramovitz 1996; Castro and Floris 1997; Abell et al. In press). Several factors contribute to the poor recognition and effectiveness of fresh-water biodiversity conservation. First, humans tend to focus their attention on terrestrial biodiversity, which is more familiar and readily observed. Second, the lack of familiarity with the full range of freshwater biodiversity leads resource managers, conservation planners, and the general public to focus primarily on species and habitats that are directly related to local and commercial human activities. Third, freshwater conservation requires great attention to large-scale dynamics, complex interactions, and linkages to terrestrial systems-all issues that are poorly understood, difficult to address effectively, and often politically challenging.

The first step toward effective conservation of freshwater biodiversity is better identification and recognition of the most critical ecosystems and existing threats to these areas. Recognizing this, the U.S. Agency for International Development (USAID) provided funding, through the Biodiversity Support Program (BSP), which enabled World Wildlife Fund and Wet-lands International to organize a joint workshop to identify priority freshwater ecoregions and assess their biological importance and level of threat. Held in September 1995 in Santa Cruz, Bolivia, the Workshop on the Conservation of Freshwater Biodiversity in Latin America and the Caribbean brought together 38 regional experts to characterize LA/C's freshwater biodiversity and identify regional priorities.

In addition to this exercise, a complementary marine analysis for LA/C, organized by The Nature Conservancy with funding from BSP, was conducted in September 1996. The methodology and identification of preliminary priorities for coastal and marine habitats are available in a separate report (Sullivan and Bustamante 1999).

To complete the picture, a parallel analysis of the conservation status of the wetlands of South America was conducted at the 1995 Santa Cruz workshop in collaboration with Wetlands International and with funding from the United Nations Environment Programme (UNEP), USAID, and the Moriah Foundation. The results of detailed regional analyses by wetland specialists were synthesized at the workshop and are available in a report from Wetlands International (Canevari et al. 1998).

Chapter 2
Approach

THE 1995 TERRESTRIAL priority-setting workshop supported by BSP found that using regional experts was the best way to gather information. Based on the success of this approach, BSP, WWF, and Wetlands International invited 38 regional experts to create a methodology appropriate for freshwater habitats. These scientists, representing both LA/C and the U.S., were identified based on their broad knowledge of biogeographic patterns of freshwater biodiversity across representative regions of LA/C (see Appendix H for a complete list of workshop participants). Over the course of five days, these participants were divided into four working groups, according to their regional areas of expertise: Mexico/Central America and the Caribbean, Amazon Basin/Orinoco and La Plata, Andes Region, and Southern Cone. During this time, the experts refined the preliminary analysis WWF had supplied prior to the workshop by providing more information on ecoregion and major habitat type (MHT) designations, biological distinctiveness, conservation status, and extraordinary features and areas of freshwater biodiversity. Finally, incorporating all of this data and assigning values to the various factors, the participants identified priority ecoregions using the integration matrix described in Chapter 4 and Appendix B. After the workshop, this analysis was further refined by WWF staff as new information was submitted by the experts, as well as by others who were unable to attend the workshop.

Goals and Targets
The freshwater priority-setting analysis was intended to help conservation donors better achieve the following fundamental goals of biodiversity conservation (Noss 1992):

o Representation of all distinct natural communities, over their range of variation, within a network of protected areas and areas managed for biodiversity conservation.

o Maintenance of ecological and evolutionary processes that create and sustain biodiversity.

o Maintenance of viable populations of species.

o Conservation of natural habitat, large enough to be responsive to large-scale periodic disturbances and long-term change.

To help achieve the four goals listed above, the regional experts focused their analysis on the following conservation targets:

Distinct Biogeographic
Units of Biodiversity

These may occur as ecoregions, communities, habitats, or assemblages, depending on the scale of analysis. Highly distinctive units constitute naturally rare opportunities for conservation. Criteria used to identify distinct biodiversity units include extraordinary species richness, endemism, taxonomic uniqueness (e.g., unique genera or families, relict species or communities, primitive lineages), and unusual ecological or evolutionary phenomena. In addition, units of globally rare ecosystems, such as seasonally inundated forests along large tropical rivers, are all considered highly distinctive at a global scale. For continent-wide analyses, the distinctiveness of each unit is evaluated at different biogeographic scales (i.e., globally, regionally, bioregionally, or locally), and relative comparisons are made only within the set of units sharing a similar MHT.

Larger Examples of Intact
Habitats and Intact Biotas
Large units of natural habitat where species populations and ecological processes still fluctuate within their natural range of variation are rapidly disappearing around the world. Therefore, remaining intact ecosystems represent rare, albeit human-induced, opportunities for conservation. Larger units are emphasized because principles of landscape (aquascape) ecology and conservation biology suggest that biodiversity will have a higher probability of persistence within such areas. Intact biotas, particularly those that still harbor their full complement of larger vertebrates, are also

increasingly rare.

Keystone Habitats,
Species, or Phenomena

At regional scales, certain habitats, species, or phenomena may have the capacity to influence surrounding habitats and ecosystems significantly. Their persistence and intact ecological functions may be critical for many species and ecological processes in neighboring biotic systems. For example, cloud forest watersheds, which are important for capturing and regulating water for downstream and adjacent lowland habitats, could be considered keystone habitat types, as could varzea forests or desert springs.

Distinctive, Large-Scale
Ecological Phenomena

Conserving distinctive, large-scale ecological phenomena, such as long-distance migration of catfish and characoid fish within the Amazon Basin, may require a combination of site-specific, regional, and policy-level efforts applied over vast continental areas or widely disjunct ecoregions. The presence of such phenomena within a particular ecoregion may contribute to its distinctiveness, but focusing conservation efforts on just one or a few ecoregions may be ineffective in conserving widespread or transient phenomena. Conservation strategies for such phenomena in freshwater ecosystems must be closely linked with ecoregion-level activities and coordinated over vast areas of the continent.

Objectives

The specific objectives of the analysis were to:

1. Delineate biogeographic units of freshwater biodiversity, or ecoregions, appropriate for a continental-scale assessment and assign them to MHTs for representation analyses (see Table 2).

2. Characterize each ecoregion in terms of its biological distinctiveness (importance) and conservation status (degree of threat) (see Table D and Table E).

3. Identify priority ecoregions for conservation action based on an integration of their biological distinctiveness and conservation status (see Table 3).

4. Highlight some of the extraordinary features and areas of freshwater biodiversity within LA/C.

5. Take initial steps to link freshwater conservation priorities with terrestrial and marine priorities identified in related analyses (Biodiversity Support Program et al. 1995; Dinerstein et al. 1995; Sullivan and Bustamante 1999).

Delineating Freshwater Ecoregions

The first step in the analysis was to delineate freshwater ecoregions that can serve as effective biogeographic units for conservation planning at regional scales. An ecoregion is defined as a relatively large unit of water or land containing a characteristic set of natural communities that share a large majority of their species, dynamics, and environmental conditions (Dinerstein et al. 1995). Ecoregions function effectively as conservation units at regional scales because they encompass similar biological communities and their boundaries roughly coincide with the area over which key ecological processes most strongly interact (Orians 1993; Noss 1996). To provide a continental perspective on biogeographic relationships, some ecoregions were "nested" within ecoregion complexes (larger biogeographic regions that encompass ecoregions sharing strong biogeographic affinities and large-scale ecological linkages). In other cases, highly distinctive or isolated ecoregions stood alone as single ecoregion complexes.

Characterizing Freshwater Ecoregions as Major Habitat Types

Major habitat types (MHTs) are natural habitats that share similar environmental conditions, habitat structure, and patterns of biological complexity (e.g., beta-diversity) and that contain species assemblages with similar guild structures and adaptations. Although MHT categories are roughly equivalent to biomes, they emphasize the ecological structure and dynamics of communities rather than the physical structure of habitats. Ecoregions categorized under the same MHT have many similar biodiversity features, such as community structures and ecological dynamics, wherever they occur around the world.

Analytical criteria for both biological distinctiveness and conservation status can be tailored to the ecological dynamics, patterns of biodiversity, and responses to disturbance characteristic of each MHT (see Abell et al. In press). Ecoregions were characterized as one of the following nine freshwater MHTs used for the LA/C region:

1. Large Rivers--large river systems draining vast continental areas, with diverse habitats including large, deep rivers, smaller tributary rivers and streams, cataracts and rapids, oxbow lakes, and flooded forests and grasslands. This habitat type is often characterized by complex flood cycles. River systems support diverse biotas with great range in body size of fish and varied resource guilds. Large-scale migration of fish species up and down rivers and in and out of flooded forests may occur.

2. Large River Deltas--deltas of large tropical rivers consisting of complex mosaics of mangroves, shifting channels, mudflats, swamp forests, and flooded grasslands, with substantial flood and tidal pulses. Many marine and brackish species are found in these deltas, in addition to freshwater forms. Large-scale riverine and oceanic migrations of fish species in and out of deltas may occur.

3. Montane Rivers and Streams--mountain rivers and streams, at elevations above 1,000 m, generally characterized by fast-flowing water, cataracts, and rapids. Biotas are often adapted to high-flow regimes.

4. Wet-Region Rivers and Streams--perennial rivers and streams in regions with abundant rainfall. This MHT encompasses a range of river and stream habitats not associated with large river systems, including relatively seasonal freshwater systems in dry forest areas, wet coastal rivers and streams, karst freshwater complexes, and island freshwater ecosystems.

5. Xeric-Region Rivers and Streams--perennial or ephemeral rivers, streams, marshes, and springs associated with xeric climates and terrestrial habitats.

6. Xeric-Region Endorheic (closed) Basins--perennial or intermittent rivers, streams, ponds, and springs that occur in xeric basins with no outlet to the sea. In this analysis, some high-elevation, closed-basins are considered within this category.

7. Flooded Grasslands and Savannas--areas where seasonal flooding produces abundant lakes, springs, wetlands, streams, and rivers over extensive grasslands or savannas.

8. Cold Streams, Bogs, Swamps, and Mires--complexes of these habitats in montane or low-latitude grasslands, steppe, woodlands, or moorlands.

9. Large Lakes--large freshwater lakes that typically occur at higher elevations in the Neotropics. Such lakes may contain fish biotas that display pronounced radiations, and endemism in a few taxa.

The above categorization also provided a framework to help track the representation of each MHT in a portfolio of conservation priorities.

Addressing the linkages between ecoregions is critical. For example, some Patagonian rivers that arise in the High Andes, such as the Limay, drain into large lakes located in wet regions, such as Lake Nahuel Huapi, continue down through xeric steppe regions, and eventually join larger rivers. Although functional linkages such as these are critically important, the MHT concept is intended to emphasize the biodiversity inhabiting and adapted to these different regions and environments.

Primary Discriminators for Analysis
Priority ecoregions were identified using two primary discriminators: biological distinctiveness and conservation status.

1. Biological Distinctiveness
The biological importance of an ecoregion can be measured by assessing the distinctiveness of its biodiversity at different biogeographic scales. All ecoregions are biologically distinct to some degree, particularly at the level of species and species assemblages, and the level of uniqueness increases at broader biogeographic scales. However, some ecoregions are so exceptionally rich, complex, or unusual that they merit extra attention from conservation planners. In practical terms, this analysis identifies the relative rarity of natural communities and indirectly estimates the extent of opportunity to conserve each distinct unit (e.g., ecoregion) and, in conjunction with other factors, helps estimate the urgency of conservation action.

The biological distinctiveness of ecoregions was assessed through an analysis of the following biodiversity features:

Species richness--with an emphasis on fish, although information on other taxa, such as crustaceans, plants, birds, and amphibians, was considered when available for comparative sets. For example, the Upper Amazon Piedmont ecoregion might be considered a globally outstanding ecoregion because of its extraordinarily diverse fish biota.

Endemism--the number and proportion of species occurring only in a particular eco-region, with an emphasis on fish. For example, ecoregions within the Rio Grande complex of Mexico are all known for exceptionally high percentages of fish endemism.

Ecosystem diversity--complexity of habitats and species distributions (e.g., beta-diversity and patterns of local endemism) within an ecoregion. Some ecoregions contain a high degree of ecosystem diversity, a phenomenon that the regional experts believed should be assessed because of its correlation to species richness. High beta-diversity (i.e., rate of species turnover along gradients or over distance) in some ecoregions may be due to either small-scale isolating mechanisms (e.g., isolated desert springs) or habitat complexity.

The final ranking of an ecoregion's biological distinctiveness was also based on the following two special considerations, which were ranked as either globally or regionally outstanding:

Rarity of major habitat type--basis for elevating ecoregions to either the globally or regionally outstanding category. High-altitude tropical lakes, main channels and deltas of large rivers, and high-altitude saline lakes were considered relatively rare at global and regional scales.

Unusual ecological or evolutionary phenomena-rare or exceptionally well-developed ecological or evolutionary phenomena (e.g., adaptive radiations) that are considered globally outstanding. In this analysis, ecoregions were elevated to a higher distinctiveness category only if their phenomena were truly globally or regionally outstanding. Examples include the extraordinary fish migrations of the Amazon Main Channel and varzea forests and the highly unusual adaptive radiations and adaptations of the biota of the Cuatro Ciénegas basin in northeastern Mexico.

If an ecoregion was thought to be either globally or regionally outstanding because of one or both of the above special considerations, then that ecoregion's final biological distinctiveness was elevated to the highest category it attained, regardless of total point score.

Based on a synthesis of the biodiversity features described above, workshop participants classified ecoregions as globally outstanding, regionally outstanding, regionally important, or locally important (see Table D). The rankings of special considerations were assigned by expert reviewers, and points were given to the species richness, endemism, and ecosystem diversity criteria with relative weightings of 2:3:1, respectively, reasoning that there are fewer opportunities to conserve unique endemic species and higher taxa. Distinctiveness categories were assigned the following point ranges out of a total of 30 points: globally outstanding (26-30), regionally outstanding (18-25), regionally important (13-17), and locally important (6-12).

Ecoregion complexes contain several ecoregions or only a single ecoregion, depending on the spatial variation in distinctive biotas within complex boundaries. To ensure appropriate biodiversity comparisons, the biological distinctiveness of an ecoregion was assessed relative only to other ecoregions in the same MHT (e.g., the biodiversity features of large-river ecoregions are compared only to other large rivers).

The regional experts recognized that measuring and assigning relative values to such complex biodiversity attributes would require a number of subjective assessments, a task made even more challenging by (1) the incompleteness of biodiversity data for many regions and freshwater taxa, (2) the fact that available data are not yet systematically and comprehensively organized at continental scales, and (3) the lack of freshwater ecoregion maps of comparable scale and classification for the world (see Revenga et al. 1998; Abell et al. In press; WCMC, In prep.). However, the regional experts believed that the conservation and resource management community had access to sufficient information on continental patterns of biodiversity (through expert opinion and technical literature) to identify ecoregions that are exceptionally distinctive at global, regional, and bioregional scales. As new data became available, some ecoregions might shift up or down one level. In general, the experts would have most confidence in classifications of globally outstanding or regionally outstanding ecoregions.

2. Conservation Status

Conservation status represents an estimate of the current and future ability of an ecoregion to maintain viable species populations, sustain ecological processes, and be responsive to short- and long-term change. An assessment of the conservation status of each ecoregion is necessary to: (1) identify MHTs and ecoregions that are most threatened so that intervention can prevent their complete degradation or conversion, (2) help create programs to conserve the most intact examples of MHTs where biodiversity and ecological processes have the best chance for persistence, and (3) help define appropriate conservation activities for different aquascape scenarios. The workshop participants assessed the conservation status of ecoregions in the tradition of The IUCN Red Data Book categories for threatened and endangered species (critical, endangered, and vulnerable). These categories of threat have gained widespread acceptance as a framework for determining the conservation status of species and populations. Such assessments have been codified into various Red Data books to call attention to species and populations considered on the verge of extinction (IUCN 1988; Mace and Lande 1991; Collar et al. 1992). Inspired by this approach, whole ecoregions were classified as critical, endangered, vulnerable, relatively stable, or relatively intact (see Table E).

These conservation status categories represent degrees of habitat alteration and spatial patterns of remaining habitats across landscapes. They reflect how, with increasing habitat loss, degradation, and fragmentation, ecological processes cease to function naturally, or at all, and major components of biodiversity are steadily eroded or altered from their pristine state. From a practical perspective, conservation status sheds light on the relative opportunity to conserve a particular ecoregion or MHT, as well as the types of conservation activities and levels of effort needed.

The categories below characterize an ecoregion's integrity as assessed by the aquascape-level indicators and qualitatively describe predicted ecological and biological impacts of loss of aquascape integrity.

Critical--Remaining intact habitat and native biotas are restricted to isolated, small fragments with low probabilities of persistence over the next 10 years without immediate or continuing protection and restoration. Many species are already extirpated or extinct due to the loss of viable habitat or the establishment of alien species. Remaining habitat fragments do not meet minimum area requirements for maintaining viable populations of many species and ecological processes. Complete assemblages of species are extremely rare. Human activities in areas between remaining fragments are often incompatible with maintaining most native species and communities. Spread of alien species may be a serious ecological problem.

Endangered--Remaining intact habitat and native biotas are restricted to isolated fragments of varying size (a few larger blocks may be present) with medium or low probabilities of persistence over the next 10 years without immediate or continuing protection or restoration. Some species are already extirpated due to the loss of viable habitat or alien species. Complete assemblages of species are rare. Remaining habitat fragments do not meet minimum area requirements for most species populations and large-scale ecological processes. Human activities in areas between remaining habitats are largely incompatible with maintaining most native species and communities. Top predators are almost exterminated.

Vulnerable--The remaining intact habitat and biotas occur in blocks ranging from large to small; many intact clusters will likely persist over the next 10 years, especially if given adequate protection and moderate restoration. In many areas, exploited species have been extirpated or are declining, particularly top predators and sensitive species. Complete assemblages of species are uncommon. Human activities in areas between remaining fragments are sometimes compatible with maintaining most native species and communities.

Relatively stable--Natural communities have been altered in certain areas, causing local declines in exploited populations and disruption of ecosystem processes. These disturbed areas can be extensive, but are still patchily distributed relative to the area of intact habitats. Ecological linkages among intact habitat blocks are still largely functional. Guilds of species sensitive to human activities, such as top predators and large game fish, are present but at densities below the natural range of variation.

Relatively intact--Natural communities within an ecoregion are largely intact, with species, populations, and ecosystem processes occurring within their natural ranges of variation. Guilds of species sensitive to human activities, such as top predators and larger fish, occur at densities within the natural range of variation. Complete assemblages of species are common. Biota move and disperse naturally within the ecoregion. Ecological processes fluctuate naturally throughout largely contiguous natural habitats.

To assign a conservation status to an ecoregion, the following aquascape-level parameters were estimated and synthesized: percentage of habitat loss (conversion or degradation of natural habitat), degree of fragmentation (a measure of the loss of linkages among habitats or areas), water quality (a measure of the physical and chemical properties of water necessary to sustain native species and ecological processes), hydrographic integrity (alterations of natural flow regimes outside of their natural range of variation), and alteration of catchment basins (degree to which whole landscapes are modified). Each indicator received a relative weighting of 20%. (Exotic or introduced species were invoked only where applicable to elevate conservation status category if high impacts were indicated.)3

For each indicator, a score of 1, 2, or 3 was assigned. A score of 3 indicated high loss or degradation, a score of 2 indicated medium loss or degradation, and a score of 1 indicated low loss or degradation. Point values for all indicators were summed and subjectively associated with the following conservation status categories: critical (15 points), endangered (12-14 points), vulnerable (8-11 points), relatively stable (6-7 points), and relatively intact (5 points).

Other potential indicators discussed at the Santa Cruz workshop included rates of habitat conversion, extent of riparian modification, degree of protection, and degree of exploitation of freshwater species. However, the difficulties associated with application and standardization of these parameters across the continent precluded using them as primary indicators at the time. Moreover, there was some discussion about how well some of these parameters indicate actual ecological integrity and intactness of the biodiversity of ecoregions (e.g., degree of protection). The effect of introduced species was only estimated for ecoregions that are highly sensitive to introduced species, such as large lakes, temperate streams, and xeric systems.

To assess aquascape-level features, the experience and knowledge of the regional experts were relied upon, since published information, spatial databases, and maps are largely unavailable, not synthesized at a continental scale, or are of poor quality or resolution for LA/C freshwater ecoregions. Current and projected threat information was gathered for different ecoregions; however, the confidence and quality of estimates for all ecoregions was inadequate for threat assessments throughout the LA/C region for this particular analysis. Thus, all conservation status assessments represent an ecoregion's current or "snapshot" status.

Identifying Priority Ecoregions

Workshop participants developed a simple integration matrix to help identify priority ecoregions for biodiversity conservation. Along the horizontal axis, the participants arranged ecoregions by their final conservation status. Along the vertical axis, they classified ecoregions by their biological distinctiveness. Conservation planners can use this matrix to determine which situations warrant the most immediate conservation attention. In order to evaluate representation among all habitat types, a separate matrix was created for each of the MHTs (see Appendix B). The matrix allowed the regional experts to classify each ecoregion into biodiversity conservation priority categories. It could be used in future studies to identify the set of conservation activities most appropriate for different conservation scenarios (i.e., combinations of biological distinctiveness and conservation status) and patterns of biodiversity associated with particular habitat or ecosystem types.

Chapter 3
Results

Ecoregions and Ecoregion Complexes

One hundred seventeen freshwater ecoregions in LA/C were identified at the workshop, based on biogeography and dynamic linkages of ecosystems, nested within 42 ecoregion complexes (see Table 1, Fig. A-1, and Appendix C). The freshwater ecoregions identified here do not necessarily correspond directly to single watersheds or to associated terrestrial ecoregions (Dinerstein et al. 1995). Major Habitat Types

The following numbers of ecoregions were categorized under each of the nine MHTs (see Table 2 and Fig. A-2):

An ecoregion was categorized as a large-river MHT if it encompassed a section of at least one large river (e.g., Amazon, Orinoco, Paraná, La Plata, Río Bravo). Four large river deltas exist in the region-Amazon, Orinoco, La Plata, and Colorado. The large-lake MHT characterizes larger, higher-elevation lakes, such as Atitlán, Titicaca, Poopó, Chapala, and the lower-elevation lakes Nicaragua and Catemaco. Xeric regions occur in northern Mexico, Patagonia, the Central Pacific Coast of South America, and the Caatinga region of eastern Brazil.

Table 2. Ranking of Major Habitat Types

Major Habitat Type	Biological Distinctiveness	Conservation Status	Priority Status
Large Rivers			
5. Rio Bravo	GO	E	1
12. Lower Rio Bravo	RO	E	2
79. Eastern Morichal	RO	RS	3
81. Southern Orinoco	GO	V	1
82. Guiana Watershed	GO	RS	2
84. Amazon Main Channel	GO	V	1
85. Northern Amazon Shield Tributaries	RO	RS	3
86. Rio Negro	GO	V	1
87. Upper Amazon Piedmont	GO	V	1
88. Western Amazon Lowlands	RO	RI	3
89. Central Brazilian Shield Tributaries	RO	V	2
90. Tocantins-Araguaia	RO	V	2
97. Upper Parana	RO	E	2
100. Lower Parana	RO	E	2
Large River Deltas			
2. Colorado Delta	RO	C	3
80. Orinoco Delta	RO	RS	3

Major Habitat Type	Biological Distinctiveness	Conservation Status	Priority Status
23. Southern Veracruz	RO	E	2
24. Belizean Lowlands	RO	V	2
25. Central American Caribbean Lowlands	RO	RS	3
28. Coatzacoalcos	RO	E	2
29. Grijalva-Usumacinta	RO	V	2
30. Yucatan	RO	V	2
32. Central American Karst Highlands	RO	V	2
33. Honduran/Nicaraguan Highlands	RI	E	3
35. Isthmus Atlantic	RI	RS	3
36. Isthmus Pacific	RI	E	3
37. Bahamas	RI	RS	3
38. Cuba	RO	V	2
39. Hispaniola	RO	E	2
40. Jamaica	RI	E	3
41. Cayman Islands	LI	V	4
42. Florida Keys	LI	E	3
43. Puerto Rico and Virgin Islands	RO	V	2

83. Amazon Delta	RO	RS	3
104. Parano-Platense Basin	RI	C	3
Montane Rivers and Streams			
26. Talamancan Highlands	LI	V	4
52. Peru High Andean Complex	RI	V	3
53. Bolivian High Andean Complex	LI	V	4
56. South Andean Yungas	RO	V	2
57. Inter-Andean Dry Valleys	LI	V	4
58. North Andean Montane	RI	E	3
59. Humid Andean Yungas	RI	V	3
60. Chuquisaca and Tarija Yungas	LI	E	3
61. Salta and Tucuman Yungas	LI	V	4
62. Sierra de Cordoba	LI	V	4
Wet-Region Rivers and Streams			
4. Sinaloan Coastal	RI	C	3
15. Santiago	RI	E	3
19. Manantlan/Ameca	RI	V	3
20. Rio Panuco	RO	E	2
21. Balsas	RI	E	3
22. Tehuantepec	RI	E	3
44. Windward and Leeward Islands	LI	E	3
45. Choco	RO	V	2
46. Magdalena	LI	C	3
47. Momposina Depression-Rio Cesar	RI	RS	3
48. Cienega Grande de Santa Marta	RI	E	3
50. Maracaibo Basin	RO	C	3
63. Puyango-Tumbes	RO	V	2
71. Juan Fernandez Islands	RI	E	3
72. Valdivian	RO	V	2
73. Chiloe Island	RO	E	2
74. Chonos Archipelago	RI	RS	3
77. Venezuelan Coast/Trinidad	LI	E	3
91. Maranhao	LI	E	3
93. East Mata-Atlantica	RO	E	2
94. Southeast Mata-Atlantica	RO	E	2
96. Cerrado	RO	E	2
101. Jacui Highlands	LI	E	3
102. Lagoa dos Patos Coastal Plain	LI	E	3
103. Chaco	RI	V	3

Biological Distinctiveness	Conservation Status	Priority Status
Globally Outstanding (GO)	Critical (C)	1 = Highest Priority for Conservation at Regional Scale
Regionally Outstanding (RO)	Endangered (E)	2 = High Priority for Conservation at Regional Scale
Regionally Important (RI)	Vulnerable (V)	3 = Priority for Conservation at Regional Scale
Locally Important (LI)	Relatively Stable (RS)	4 = Important at Subregional and Local Scales
	Relatively Intact (RI)	

Table 2. *(Continued)*

Major Habitat Type	Biological Distinctiveness	Conservation Status	Priority Status
Xeric-Region Rivers and Streams			
1. Baja California	LI	V	4
3. Sonoran	LI	E	3
6. Pecos	RO	E	2
11. Conchos	RO	E	2
13. Rio San Juan	RO	E	2
14. Rio Salado	RI	E	3
16. Chapala	GO	E	1
18. Rio Verde Headwaters	RO	E	2
49. Guajira Desert	RI	V	3
64. Atacama/Sechura Deserts	LI	C	3
65. Pacific Coastal Deserts	RI	E	3
68. Galapagos	LI	RS	4
69. North Mediterranean Chile	RO	C	3
70. South Mediterranean Chile	RO	E	2
92. Northeast Mata-Atlantica	RO	E	2
95. Caatinga	RO	E	2
109. Rio Colorado	RI	V	3
110. Rio Limay-Neuquen-Rio Negro	RO	V	2
112. Rio Chubut-Rio Chico	RO	V	2
8. Mapimi	RI	E	3
9. Cuatro Cienegas	GO	V	1
10. Llanos El Salado	RO	E	2
17. Lerma	RO	C	3
54. Arid Puna	RO	V	2
55. Subandean Pampas	RO	V	2
106. Northwest Pampas Basins	LI	V	4
108. Southwest Pampas Basins	LI	V	4
111. Meseta Somuncura	RO	V	2
Flooded Grasslands and Savannas			
78. Llanos	GO	V	1
98. Beni	RI	V	3
99. Pantanal	GO	V	1
105. Rio Salado and Arroyo Vallimanca Basin	RI	V	3
107. Pampas Coastal Plains	LI	V	4
Cold Streams, Bogs, Swamps, and Mires			
51. Paramos	RO	RS	3
75. Magallanes/Ultima Esperanza	RI	RI	4
76. Subantarctic	LI	RI	4

113. Rio Deseado	LI	V	4
114. Rio Santa Cruz-Rio Chico	LI	V	4
115. Rio Coyle	RO	V	2
116. Rio Gallegos	LI	V	4
117. Tierra del Fuego-Rio Grande	RI	RS	3
Xeric-Region Endorheic (closed) Basins			
7. Guzman	RI	E	3

Large Lakes			
27. Catemaco	RO	V	2
31. Guatemalan Highlands	RO	V	2
34. Lake Nicaragua	RO	E	2
66. Lake Titicaca	GO	V	1
67. Lake Poopo	RI	C	3

Biological Distinctiveness	Conservation Status	Priority Status
Globally Outstanding (GO)	Critical (C)	1 = Highest Priority for Conservation at Regional Scale
Regionally Outstanding (RO)	Endangered (E)	2 = High Priority for Conservation at Regional Scale
Regionally Important (RI)	Vulnerable (V)	3 = Priority for Conservation at Regional Scale
Locally Important (LI)	Relatively Stable (RS)	4 = Important at Subregional and Local Scales

Amazon (see Appendix D and Fig. A-3). Fifty-one ecoregions (44%) were considered regionally outstanding (RO) (i.e., within the Neotropical region; Nearctic for northern Mexico). Thirty ecoregions (26%) were considered regionally important (RI), while 25 (21%) were assessed as locally important (LI).

estimated as greatest in the ecoregions of the Amazon Complex and the Guiana-Orinoco Complex. Freshwater ecosystems in the Amazon Basin, and perhaps portions of the Orinoco region, harbor the richest freshwater fish faunas on Earth. The Galápagos Islands have limited freshwater habitats and no fish species.

Biological Distinctiveness

Eleven ecoregions (9%) were considered as globally outstanding (GO) in terms of their biological distinctiveness, particularly in regions of the western arc of the Amazon River Basin, Southern Orinoco, Río Negro, Chihuahuan Desert, high-elevation lakes of central Mexico, Llanos, Guiana Watershed, and varzea flooded forests of the Amazon (see Appendix D and Fig. A-3). Fifty-one ecoregions (44%) were considered regionally outstanding (RO) (i.e., within the Neotropical region; Nearctic for northern Mexico). Thirty ecoregions (26%) were considered regionally important (RI), while 25 (21%) were assessed as locally important (LI).

Species Richness

Species richness for a range of taxa was estimated as greatest in the ecoregions of the Amazon Complex and the Guiana-Orinoco Complex. Freshwater ecosystems in the Amazon Basin, and perhaps portions of the Orinoco region, harbor the richest freshwater fish faunas on Earth. The Galápagos Islands have limited freshwater habitats and no fish species.

Endemism

Ecoregions known for a large number of endemic fish species include the Guiana-Orinoco Complex (e.g., Guayanan Highlands and Guiana Watershed) and the Upper Amazon Piedmont. Regional centers of endemism (i.e., ecoregions with a high percentage of endemic species) include the Rio Grande/Río Bravo Complex (Río Bravo, Cuatro Ciénegas, Llanos El Salado, and Lower Río Bravo ecoregions), Guayanan Highlands (Southern Orinoco), Piedmont regions of the western Amazon Basin, Llanos, Mata-Atlântica region of Brazil, Lerma/Santiago Complex (particularly the Chapala ecoregion), Río Verde Headwaters, Southern Veracruz, Catemaco, Grijalvo-Usumacinta, Cuba, Hispaniola, Southern Orinoco, Río Negro, and Lake Titicaca ecoregions. The biota of several ecoregions in the Southern Cone display high percentages of endemic invertebrate and vertebrate species; these include the Colorado River, Meseta Somuncura, Río Limay-Neuquén-Río Negro, and Tierra del Fuego-Río Grande.

Two general patterns of pronounced endemism appear to occur in the region. Evolutionary phenomena associated with isolated basins, particularly in xeric regions, or large, older lakes promote differentiation or radiation with a few lineages. Cuatro Ciénegas, Titicaca, and Chapala ecoregions are good examples. Ecoregions with especially diverse faunas, especially those at the periphery of large basins, also appear to support a high proportion of endemic taxa. Examples include the ancient Guayanan Highlands, Río Negro, and Guiana Watershed. Further study of these patterns is needed.

Ecosystem Diversity

Ecoregions in a variety of MHTs were characterized as having high ecosystem diversity. Large rivers, such as the Amazon, Río Negro, Río Bravo (Grande), and Orinoco harbor a diverse set of freshwater habitats and communities. Large lakes, such as Titicaca, Poopó, and Chapala, were also considered to support diverse freshwater habitats. The Llanos, Eastern Morichal, and Chaco constitute tropical savannas with a complexity of freshwater systems, while several, more temperate grassland and savanna areas of the Southern Cone also were assessed as supporting diverse freshwater ecosystems. The Yucatán was noted for diverse and unusual freshwater ecosystems.

Rarity of Major Habitat Type

Several ecoregions were considered rare at global and regional scales in terms of their habitat types, including large rivers, large river deltas, and complex flooded savannas. Some ecoregions that received such distinction include the Llanos, Orinoco River Delta (Amacuro Delta), Southern Orinoco, and Amazon River Delta and Main Channel. The extensive, seasonally flooded forests of the Amazon and Orinoco rivers represent a globally rare freshwater habitat type.

Unusual Ecological or Evolutionary Phenomena

The extraordinary migrations of fish and invertebrate species between the varzea flooded forests of the Amazon and Orinoco basins are unrivaled in terms of the diversity and abundance of migrating species. Many of the adaptations of varzea species, such as specialized frugivory seen in a variety of fish species, are highly unusual at a global scale. The long-distance migrations of catfish and other fish within the Amazon Basin are also remarkable.

Most of the larger lakes of LA/C, including Titicaca, Atitlán, Catemaco, and Chapala, have unusual radiations of fish taxa with a high proportion of endemic species and genera. The highland lakes and wetlands of the central highlands of Mexico are also known for a number of endemic invertebrates and frogs.

The evolutionary adaptations and radiations seen in the highly distinctive biota of Cuatro Ciénegas is extraordinary at a global scale. Cuatro Ciénegas is a relatively small basin in the central Chihuahuan Desert. Spring-fed pools and streams have supported a globally distinctive fauna with high levels of endemism, extreme local ranges (several square meters for some snails), and highly unusual radiations and adaptations (Minckley 1978; Almada and Contreras Balderas 1984). This is the only place in the world where one finds aquatic box turtles and a species of cichlid fish that has two distinctive forms, one a snail specialist and the other an algae feeder. The long isolation of this basin since the Pleistocene has contributed to its unique biota. Although similar phenomena occur in other basins in the region, Cuatro Ciénegas is the largest and most outstanding example of this freshwater biodiversity phenomena.

Other Important Freshwater Biodiversity Features

Critical Habitats for Large-scale Ecological Phenomena. Throughout the LA/C region, freshwater habitats provide critical wintering, feeding, resting, and breeding habitat for many species of migratory birds (Finlayson and Moser 1991; Dugan 1993; WHSRN 1993; Elphick 1995). Some of these habitats are of hemispheric importance because of the diversity of species and great numbers of individual shorebirds, wading birds, and waterfowl that depend on them. Examples of important sites include Copper-name Delta, Bigi Pan, Wia-Wia, Lagoa do Peixe, Llanos, Mar Chiquita, Maranhão wetlands complex, Southern Cone wetlands, and the Marismas Nacionales complex of Mexico. Although some of these freshwater ecosystems may be depauperate in fish, crustacean, and other freshwater species, as well as having few, if any, endemic species, they are critically important for maintaining the large-scale ecological phenomena of inter- and intra-continental bird migrations. In some cases, such as the Llanos, the fresh-water biota is both rich and endemic and the ecoregion is important for migratory birds. Priority sites and activities for conserving such large-scale migratory processes have been effectively identified through analyses by Wetlands International, IUCN, RAMSAR, and others (e.g., Canevari et al. 1998).

Mangroves. Mangroves encompass fresh-water, marine, and terrestrial ecosystems. Although mangroves support few tree species in the Neotropics, these habitats may rival tropical forests in species richness if all the aquatic, amphibious, and terrestrial species living in or dependent upon mangroves for some stage of their life cycle are counted together. The conservation status of LA/C mangroves has been assessed elsewhere (see Olson et al. 1996; Spalding, Blasco, and Field 1997).

Conservation Status
Results of the conservation status analysis are as follows (see also Appendix E and Fig. A-4):

o Nine (8%) ecoregions were considered critical (C), 43 (37%) endangered (E), 49 (42%) vulnerable (V), 13 (10%) relatively stable (RS), and 3 (3%) relatively intact (RI).

o More than 85% of the freshwater ecoregions of LA/C were ranked as critical, endangered, or vulnerable.

o Critical ecoregions were found in the Caribbean lowlands and intermontane valleys of Colombia, Maracaibo Basin, Lake Poopó, the delta of the Colorado River, coastal Sinaloa, Lerma and Lake Patzcuaro of central Mexico, Atacama/ Sechura deserts, Parano-Platense delta, and northern portions of the Mediterranean region of Chile.

o Endangered regions included much of the freshwater systems of the cerrado and Atlantic region of Brazil, northern and southern Mexico, higher-elevation ecoregions of the northern Andes, and the coastal deserts of Peru and Chile.

o Some of the more intact ecoregions occur in the central Amazon River Basin, Guianas and Guayanan Highlands, and some lowland Caribbean ecoregions of Central America.

Chapter 4
Findings and Conclusions

Priority Ecoregions
At the Santa Cruz workshop, regional experts agreed upon a series of cells in the integration matrix that would qualify as highest priority (see Table 3 below).

[insert Table 3]

The following four priority levels for conservation action were recognized:

1) Highest Priority for Conservation Action at Regional Scale. These are globally outstanding ecoregions that are either endangered or vulnerable and that require immediate conservation intervention.

Globally outstanding ecoregions that are relatively intact were not identified as highest priority at this juncture because of the urgency of more threatened ecoregions. There was agreement that ecoregions in this category are critically important to conserve, warrant constant vigilance against threats, and present situations where conservation efforts can be cost-effective. Moreover, some aquatic species inhabiting relatively intact ecoregions are highly threatened throughout their range due to intensive hunting.

2) High Priority for Conservation Action at Regional Scale. These are globally outstanding ecoregions that are critical or relatively stable and regionally outstanding ecoregions that are endangered or vulnerable.

Globally and regionally outstanding ecoregions whose final conservation status was critical were ranked as second and third priority, respectively, for conservation action. This was due, in part, to the extreme difficulty of restoring critical freshwater ecosystems because of the strong dynamic linkages throughout the entire ecoregion (i.e., the necessity of interventions at the scale of whole watersheds). In contrast, this combination of features was selected as highest priority in a previous WWF analysis of terrestrial ecoregions of LA/C (Dinerstein et al. 1995).

3) Priority for Conservation Action at Regional Scale. This category includes globally outstanding ecoregions that are relatively intact; regionally outstanding ecoregions that are considered critical, relatively stable, or relatively intact; regionally important ecosystems that are critical, endangered, vulnerable, or relatively stable; and locally important ecosystems that are either critical or endangered.

4) Important at Subregional and Local Scales. This category includes regionally important ecoregions considered relatively intact and locally important ecoregions that are vulnerable, relatively stable, or relatively intact.

Regional Patterns of Threat

A review of the information gathered on threats to freshwater biodiversity revealed the following:

o The type, intensity, and scale of threats vary among regions and MHTs. Widespread and pervasive threats include dams, water diversions, draining and channelizations, pollution from toxins and eutrophication, loss of riparian and catchment basin forests with associated changes in sedimentation and physical conditions, introduced species, and overexploitation of freshwater species.

o Freshwater ecosystems and habitats in xeric (drier) climates are highly threatened throughout the region (e.g., Contreras Balderas 1978a, 1978b; Contreras Balderas and Escalante 1984). Diversion of water for human activities, intensive grazing of alien species, and destruction of riparian vegetation are major causes.

o Three of the most endangered habitat types are large river floodplains, such as floating meadows and varzea forests, which are threatened by logging and conversion to pasture; cataracts, which are lost over vast areas due to dams and water diversions; and desert springs.

o Major habitat types (MHTs) particularly sensitive to human disturbance are freshwater ecosystems in xeric regions and high-altitude lakes.

o Intensive coffee production and other agriculture in many montane areas have damaged streams through sedimentation, eutrophication, pesticides, and loss of riparian vegetation.

o Loss and degradation of headwater habitats can seriously impact the ecological processes, dynamics, and biodiversity of entire watersheds.

o Small wetlands complexes can be as important as large wetlands for wintering and breeding habitat for migratory birds. Many smaller wetlands are being degraded or destroyed across whole landscapes.

o Pollution from gold mining (mercury) and petroleum industry activities (e.g., oil spills in the Napo region of Ecuador) is becoming increasingly widespread and severe as relatively unregulated exploitation spreads into more intact regions.

o Several large freshwater species that are intensively hunted throughout their range are threatened, even in relatively stable or intact ecoregions, including giant river otters (Pteronura brasiliensis); black caiman (Melanosuchus niger); Amazonian manatee (Trichechus inunguis); West Indian manatee (T. manatus); freshwater dolphins, such as the tucuxi (Sotalia fluviatilis) and boutos (Inia boliviensis and I. geoffrensis); bony fish, such as arapaima or pirarucu (Arapaima gigas); and giant river turtles (e.g., Podocnemis expansa). For example, giant river otters were once distributed widely across the lowland rivers of tropical South America. Today, less than 1,000 individuals are estimated to survive in the wild, and most of these are in highly fragmented populations of small size. Like several other large, freshwater species, otters are highly sensitive to hunting because of their large size, gregarious habits, and lack of avoidance of humans.

o More than 85% of the freshwater biodiversity of LA/C is seriously threatened in terms of geographic extent and severity of threats, 25% higher than the 60% assessed for LA/C's terrestrial biodiversity (Dinerstein et al. 1995). Abell et al. (In press) have found a similar pattern in North American ecoregions.

Table 4. Priority Freshwater Ecoregions for Regional-level Conservation Action

Highest Priority	Rio Bravo	5	Southern Orinoco	81
	Cuatro Ciénegas	9	Amazon Main Channel	84
	Chapala	16	Río Negro	86
	Lake Titicaca	66	Upper Amazon Piedmont	87
	Llanos	78	Pantanal	99
High Priority	Pecos	6	Arid Puna	54
	Llanos El Salado	10	Subandean Pampas	55
	Conchos	11	South Andean Yungas	56
	Lower Río Bravo	12	Puyango-Tumbes	63
	Río San Juan	13	South Mediterranean Chile	70
	Río Verde Headwaters	18	Valdivian	72
	Río Panuco	20	Chiloé Island	73
	Southern Veracruz	23	Guiana Watershed	82
	Belizean Lowlands	24	Central Brazilian Shield Tributaries	89
	Catemaco	27	Tocantins-Araguaia	90
	Coatzacoalcos	28	Northeast Mata-Atlântica	92
	Grijalva-Usumacinta	29	East Mata-Atlântica	93
	Yucatán	30	Southeast Mata-Atlântica	94
	Guatemalan Highlands	31	Caatinga	95
	Central American Karst Highlands	32	Cerrado	96
			Upper Paraná	97
	Lake Nicaragua	34	Lower Paraná	100
	Cuba	38	Río Limay-Neuquen-Río Negro	110
	Hispaniola	39	Meseta Somuncura	111
	Puerto Rico and Virgin Islands	43	Río Chubut-Río Chico	112
	Chocó	45	Río Coyle	115

Developing a Conservation Strategy for Freshwater Biodiversity

Overall, 10 (9%) ecoregions were considered highest priority for conservation action at the regional scale (priority status of 1 in Tables 1 and 2), 41 (35%) as high priority at the regional scale (priority status of 2 in Tables 1 and 2), 50 (42%) as priority at the regional scale (priority status of 3 in Tables 1 and 2), and 16 (14%) as important at subregional and local scales (priority status of 4 in Tables 1 and 2). Table 4 shows the freshwater ecoregions (including their ecoregion numbers) recommended as highest priority or high priority for conservation action at the LA/C regional level (see also Fig. A-5):

Priority freshwater ecoregions that generally overlap with the terrestrial priority ecoregions identified in a WWF analysis by Dinerstein et al. (1995) include the Chihuahuan Desert; Guayanan Highlands; Western Arc of the Amazon; Llanos; varzea and igapó forests of the Amazon and Orinoco; Pacific coastal ecoregions of Colombia and Ecuador; ecoregions of the Brazilian Shield, Cerrado, and Atlantic Coast of Brazil; high-altitude lakes of the southern Andes; Mediterranean region of central Chile; central Patagonia; and Hispaniola.

Conclusions

Whereas almost no prioritization of freshwater ecoregions had been done in the past, participants at the Santa Cruz workshop have now identified a subset of 10 highest priority ecoregions and 41 high- priority ecoregions out of an original 117 LA/C ecoregions. Areas of outstanding freshwater biodiversity and significant threats for an entire biogeographic realm (the Neotropics and part of the Nearctic) have been identified in a single document, and maps have been designed to inform conservation planners and investors in their decision-making. Taking into account the priority-setting models and regional patterns of threats presented in this study can help determine the most appropriate set of general conservation activities for different areas, habitat types, and situations.

This study emphasizes the following: (1) the concept of representation of major freshwater habitat types in conservation portfolios; (2) the overriding importance of aquascape-level features and dynamics in the long-term viability and persistence of ecosystems and their biodiversity; (3) the need to assess ecological and evolutionary phenomena as important elements of biodiversity; and (4) the importance of tailoring analytical criteria to the particular patterns of biodiversity, ecological dynamics, and responses to disturbance of different MHTs. Some differences and linkages between freshwater and terrestrial conservation planning efforts have also been highlighted. Sound conservation activities for terrestrial biodiversity can have significant conservation benefits for associated freshwater biodiversity.

As this conservation assessment shows, with such intense and pervasive threats, effective and timely implementation of freshwater conservation strategies is urgently needed to prevent large-scale degradation of these precious resources.

We encourage USAID and other donors to use this study to analyze their current investments in freshwater ecosystems in LA/C and, wherever possible, to increase their investments in the priority freshwater areas highlighted. This does not mean that funding for lesser priority regions should be discontinued. All other areas are considered appropriate for continued biodiversity conservation investments at the national and local levels. Donors should use the results of this exercise to diversify their biodiversity investments into ecoregions across the full spectrum of conservation status, from critical to relatively intact, especially since investing now in more areas will save money later on.

We sincerely hope that this initial effort will catalyze future actions that, linked with companion measures to conserve terrestrial and marine systems, will result in the conservation and restoration of the freshwater biodiversity systems of Latin America and the Caribbean.

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APPENDIX A

1 Freshwater Ecoregions and Ecoregion Complexes

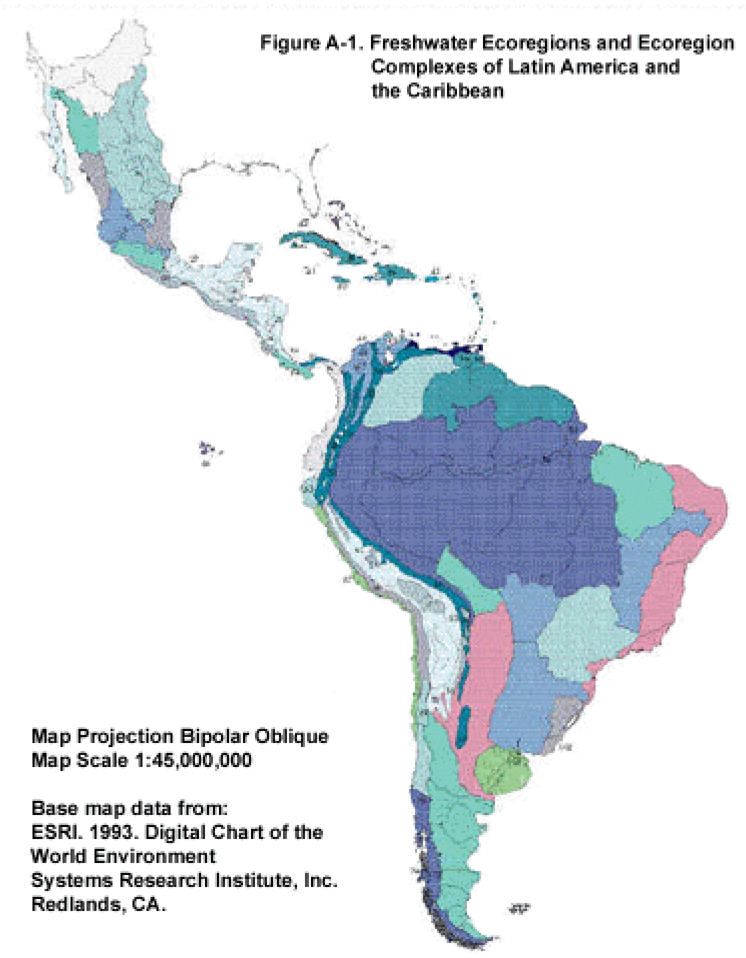

Figure A-1. Freshwater Ecoregions and Ecoregion Complexes of Latin America and the Caribbean

2 Major Habitat Types

3 Biological Distinctiveness

4 Conservation Status

5 Regional Priorities

APPENDIX B

Distinctiveness and Conservation Status

APPENDIX B

1. Large Rivers

Final Conservation Status

Biological Distinctiveness	Critical	Endangered	Vulnerable	Relatively Stable	Relatively Intact
Globally Outstanding		5. Rio Bravo - Mexico, U.S.	81. Southern Orinoco - Colombia, Venezuela, Brazil 84. Amazon Main Channel - Brazil, Peru 86. Rio Negro - Brazil 87. Upper Amazon Piedmont - Bolivia, Brazil, Colombia, Ecuador, Peru	82. Guiana Watershed - Brazil, Guiana, French Guiana, Suriname	
Regionally Outstanding		12. Lower Rio Bravo - Mexico, U.S. 97. Upper Parana - Brazil 100. Lower Parana - Argentina, Brazil, Paraguay, Uruguay	89. Central Brazilian Shield Tributaries - Bolivia, Brazil 90. Tocantins - Araguaia - Brazil	79. Eastern Morichal - Venezuela 85. Northern Amazon Shield Tributaries - Brazil	88. Western Amazon Lowlands - Bolivia, Brazil, Colombia, Peru
Regionally Important					
Locally Important					

2. Larger River Deltas

Final Conservation Status

Biological Distinctiveness	Critical	Endangered	Vulnerable	Relatively Stable	Relatively Intact
Globally Outstanding					
Regionally Outstanding	2. Colorado Delta - Mexico			80. Orinoco Delta - Venezuela 83. Amazon Delta - Brazil	
Regionally Important	104. Parano-Platense Basin - Argentina, Uruguay				
Locally Important					

3. Montane Rivers and Streams

Final Conservation Status

Biological Distinctiveness	Critical	Endangered	Vulnerable	Relatively Stable	Relatively Intact
Globally Outstanding					
Regionally Outstanding			56. South Andean Yungas - Bolivia, Peru		

Regionally Important		58. North Andean Montane- Colombia, Ecuador, Peru, Venezuela	52. Peru High Andean Complex - Bolivia, Peru 59. Humid Andean Yungas - Bolivia, Peru		
Locally Important		60. Chuquisaca and Tajira Yungas - Bolivia	26. Talamancan Highlands - Costa Rica, Panama 53. Bolivian High Andean Complex - Argentina, Bolivia 57. Inter-Andean Dry Valleys - Argentina , Bolivia 61. Salta and Tucuman Yungas - Argentina 62. Sierra de Cordoba -	Argentina	

APPENDIX C

Freshwater Ecoregion Descriptions

THE FOLLOWING SUMMARIES describe the geographic extent, biology, and threats associated with the nested ecoregions and ecoregion complexes of Latin America and the Caribbean. These summary sketches were transcribed from information provided by regional experts who participated in the September 1995 workshop held in Santa Cruz, Bolivia. Descriptions cover geographic boundaries and biological and threat characteristics. Selected sketches also include human utility and recommendations for conservation action. Additional information on the freshwater biodiversity of these regions can be found in Revenga et al. (1998), Abell et al. (In press), WCMC (In prep.), CONABIO, and other sources listed in the text and Appendix G.

I. MEXICO, CENTRAL AMERICA, AND THE CARIBBEAN

Baja California Complex

1. Baja California--coastal streams of the Baja California peninsula, excluding the Colorado River and deltaic tributaries. Usually high altitude, coastal cryptorheic, or isolated mountain streams in the northern part, canyon-contained streams in the central areas, and desert habitats at lower reaches. Development of the peninsula during the Miocene led to isolation of various Nearctic taxa, and subsequent speciation within groups, such as the fish genus Fundulus (Espinosa-Pérez et al. 1993).

Colorado River Complex

This complex includes the Colorado River Basin and Range province, Mojave Basin, Lahontan Basin, Upper Basin and Gila, mostly in the United States. In western Mexico, this complex includes the Colorado Delta, and runs along the Sonoran coastal plain to the Río Yaqui Basin, except for the headwaters. Also included are numerous and complex isolated basins, some with terminal lagoons. Most is high desert, cutting the Rocky Mountains through the Grand Canyon, and continuing through low desert on the coastal plain, with a wide and complex deltaic area.

2. Colorado Delta--subset of the Colorado Ecoregion (see Abell et al. In press). Wide area of tidal flatland, subject to strong variations of sea level. Dry course with numerous alternative minor courses and former outlets to the sea. Low species richness but high degree of endemism in freshwater fish, many of which have evolved special adaptations to survive naturally high flow, high turbidity conditions of the main river. The effects of the Hoover Dam are felt this far downstream. Other threats include regional-scale water overexploitation and aquifer depletion, industrial and agricultural pollution, exotics, human population growth, and habitat destruction and fragmentation.

3. Sonoran--extends from Río Sonoyta to the Río Yaqui and intervening small basins, most of them cryptorheic, through desert and semi-desert areas, west of the Sierra Madre Occidental. Includes the small area of the Gila River headwater fish community that has become extinct in Mexico. Desert rivers, such as the Sonoyta, support only freshwater-derived fish, while larger rivers to the south tend to contain many additional marine species (Minckley, Hendrickson, and Bond 1986).

Sinaloan Coastal Complex
4. Sinaloan Coastal--runs from Río Mayo (except perhaps headstreams) to Río Presidio (except head-waters), draining to the Gulf of California. Some headwaters come from the Mesa del Norte through the Sierra Madre Occidental. Like the Sonoran, large rivers contain many marine fishes.

Río Bravo Complex
5. Río Bravo--mostly semi-arid region, with some large tributaries draining from the Sierra Tarahumara and the Rockies to the Gulf of Mexico. Contains numerous interior basins derived from it and isolated spring systems and springs. This ecoregion is strongly associated with the Missouri/ Mississippi provinces. The Upper Rio Grande (Río Bravo) is species poor compared to the nearby Pecos (Smith and Miller 1986).

6. Pecos--contains a great diversity of habitats, from mountain headwaters to the main rivers. Headwaters formerly comprised a tributary to the Rio Grande, and another portion of the Pecos may have been a head-water tributary of streams on the Gulf Slope of southern Texas (Smith and Miller 1986). Historically, supported a number of endemic fishes and other taxa, including three pupfish (Cyprinodon spp.). Major threats include extensive irrigation diversion, groundwater pumping, and reservoir storage; oil field pollution, exotic species, and habitat alteration (Williams et al. 1985).

7. Guzmán--endorheic complex of short rivers, originating high in Sierra Tarahumara, with flood plain in the Mesa del Norte, and with outlets in several terminal lagoons. Former tributaries of the Río Bravo, comprising Ríos Casas Grandes, Santa María, Carmen, Sauz and other minor interior basins, Upper Yaquí, Upper Fuerte, and some isolated spring systems. High-elevation parts of this ecoregion are relatively inaccessible and undisturbed, but lower areas are more threatened by development and water use (Williams et al. 1985).

8. Mapimí--complex endorheic group of rivers and terminal lagoons including isolated Ríos Nazas, Aguanaval, Parras, Lago de Santiaguillo, Upper Mayo, Upper Presidio, and Upper Mezquital, as well as associated springs of each. Fish fauna comprises species most closely related to groups located primarily in the Río Bravo or the Río Lerma basins, a function of past connections.

9. Cuatro Ciénegas--covers only the Valle de Cuatro Ciénegas, an intermontane valley with a gypsum to rocky floor, highly isolated from Río Salado, located at, or close to, its headwaters. Has more than 30 large springs or spring systems, with thermal to freshwater, of low to high salinities, and usually highly alkaline. Extraordinary endemism of fish and snails, with some species restricted to small pools. A single species of cichlid displays two forms, one a snail specialist and the other an algal feeder. The only aquatic box turtle is found here. Unusual subterranean fauna occurs in underground streams.

10. Llanos El Salado--comprises a number of isolated basins with springs or spring systems, derived from the old Pluvial Rio Grande. Generally alkaline waters. Localized on the plateau, and now remote from other waters. A number of endemic fish and other taxa (including crayfish) are found here, as well as two endemic fish genera (Xenoophorus and Megupsilon). Threats include the depletion of aquifers, agricultural clearings, exotic species, and human population growth.

11. Conchos--Río Conchos sub-basin, associated spring systems, and some endorheic lagoons formerly part of the sub-basin, like Río Sauz-Encinillas, Laguna de Bustillos, and Laguna de los Mexicanos. Stems from a wide area high along the Sierra Tarahumara, and traverses a complex flood plain on the Mesa del Norte before draining into the Río Bravo. Also includes its main stem between the Río Conchos mouth to (but not including) that of Río Pecos.

12. Lower Río Bravo--covers the main stem Río Bravo below the Pecos outlet, and includes the region of high flow springs around the middle Río Bravo and down to the Lower Valley and river mouth on the Gulf of Mexico. Most of it runs through the coastal plain in a low course.

13. Río San Juan--includes the relatively large tributary, Río San Juan, and the associated sub-basin, Río Alamo, originating in some high intermontane valleys or in deep canyons of the Sierra Madre Oriental. Runs over flood plain and down the coastal plains to join the Río Bravo. Includes at least five endemic fish species, as well as an endemic crayfish and several species of other aquatic invertebrates. Threats include the overexploitation of water resources, salinization resulting from industrial and agricultural practices, human population growth, exotic species, and dams.

14. Río Salado--includes Río Salado sub-basin, with some derived lacustrine sub-basins. Relatively flat and uniform on the lower plains. Includes low springs or small low canyons, with some headwater large springs. Seven endemic fish species are found here, including an endemic genus (Prietella). Major threats include agricultural development, land clearing, industrial pollution, water pollution, exotic euryhaline (salt-tolerant) species, and salinization of freshwater.

Lerma/Santiago Complex
The region is characterized by some large rivers and lakes formed independently, as well as major and minor lacustrine endorheic basins derived and isolated from those rivers. Lost headwaters are captured by neighboring rivers, and springs are associated to each of them. The complex has heavy tectonic and volcanic activity.

15. Santiago--medium-large river, with strong seasonal changes, formed by the main stem Río Santiago below the Salto (waterfall) de Juanacatlán, and the Lower Río Mezquital, with numerous relatively important tributaries stemming from the Central Plateau, and cutting through the Sierra Madre Occidental by deep and complex canyons. Also includes some interior crater lakes in Hayarit and Jalisco. Isolated from neighboring basins.

16. Chapala--includes only the large Lake Chapala and minor basins draining into it. The lake is generally shallow, with weak water currents due to its large size and shallow depth.

17. Lerma--covers mainly Río Lerma and tributaries, including endorheic Valley of Mexico and some southwestern headwaters of Río Panuco. Origin of the basin differs from that of Río Santiago, probably captured from a different system.

18. Río Verde Headwaters--contains a relatively small number of fauna characterized by high endemism (over 50%). Two endemic fish genera (Cualac and Ataeniobius) are found here. Major threats include agricultural expansion, water depletion, exotic species, channelization for irrigation, and human population growth.

19. Manantlán/Ameca--covers minor coastal basins of Jalisco, draining the coastal area, almost without pluvial plain and extending from the small streams around the Bahia de Banderas to the Río Mascota, Río Ameca to Río Manantlán, perhaps southeastward to, but not including, the Río Balsas.

Río Panuco Complex
20. Río Panuco--large river system, with some associated isolated interior basins, including the slightly distinct independent basin of Río Soto la Marina to the north, and the coastal streams north of Punta del Morro (Veracruz), but excluding some southwestern headwaters (Río Tula, Río San Juan, etc.), that were captured from the Río Lerma headwaters. It traverses the Sierra Madre Oriental, often through deep canyons and steep gradients.

Balsas Complex
21. Balsas--river that traverses massive mountainous areas, carving deep canyons and running high sloped courses, with fast-running waters. Contains an estimated 35 percent endemism in fish species, which are threatened by dams and other development (Espinosa-Pérez et al. 1993).

Pacific Central Complex
22. Tehuantepec--extends from the Pacific Ocean at Puntarenas to the Atlantic-Pacific divide, northwest along the Atlantic-Pacific drainage divide, west of Lake Nicaragua, then northeast, north and west along the Atlantic-Pacific

drainage divide to Río Balsas, then northeast to the Atlantic-Pacific divide.

Atlantic Central Complex

From the Golfo de Mosquito, Costa Rica, the complex extends southwest to the Atlantic-Pacific divide to Locano Irazu; it runs northwest on Atlantic-Pacific drainage divide, through Cordillera Central/Guanacaste, midway through the western shore of Lago de Nicaragua and western shore of Lago Managua (alongside drainage divide of Atlantic-Pacific divide). It extends along the drainage divide to Cordillera Marrabios, and continues northeast, north, and northwest along Atlantic-Pacific drainage divide through Honduras, Guatemala, and into southern Mexico, including some interior basins, including Comitan and the Montebello system of Chiapas-Guatemala.

23. Southern Veracruz--comprises mainly the large Río Papaloapam and includes minor coastal basins from Punta del Morro south, but does not include the Tuxtlas. The river rises from high in the Sierra Madre del Sur, with some high headwaters. The lower course has a complex and sinuous flood plain, terminating in the large coastal Laguna del Alvarado.

24. Belizean Lowlands--covers coastal lowlands at elevations of less than 200 m from Río Motagua, Guatemala northward to the area just north of Laguna Bacala, Mexico on the Yucatán Peninsula. Slow-moving rivers with associated floodplains, grading into mangroves as they approach the Caribbean Sea. Compared to the Central American Caribbean lowland ecoregion, the coastal plain is small in size, except in the Belize and Mexico portions.

25. Central American Caribbean Lowlands--coastal lowlands at elevations less than 200 m from Santa Catalina, located east of Peninsula Valiente, Panama, north and west to the area just east of Río Motagua, Guatemala. Slow-moving rivers with associated floodplains, grading into mangroves as they approach the Caribbean Sea. The highly productive coastal plain is broad from Puerto Limón, Costa Rica to Pt. Patuca, Honduras.

26. Talamancan Highlands--rugged upland areas extending from Panama to the border of Costa Rica and Nicaragua. Starting from the headwaters of the Cordillera de Talamanca to Volcán Orosí. From Volcán Orosí, along the 200-m contour level of the Atlantic watershed, extends southeast to Cordillera Central to the town of Río Luis, and south to Cordillera Central divide.

27. Catemaco--covers the volcanic Lago de Catemaco and its tributaries, downstream to the Salto de Eyipantla, including isolated Laguna Esmerelda and other smaller lagoons high in the Sierra de los Tuxtlas.

28. Coatzacoalcos--comprises mainly the Río Coatzacoalcos, its lower lacustrine and swamp system, and some minor coastal drainages near its mouth.

29. Grijalva-Usumacinta--combines the large Ríos Grijalva, Usumacinta, and the endorheic basins of Río Comitán and Lagunas de Montebello. Southern tributaries start on the southern plateau, descend (sometimes through deep canyons) and have a complex delta of many alternative courses and coastal lagoons.

30. Yucatán-includes coastal streams and interior basins, grottos, cenotes (sinkholes), and aguadas (small cenotes) of the Yucatán Peninsula.

31. Guatemalan Highlands--small and sinuous Atlantic drainage upland region (elevation greater than 200 m) in Guatemala, Belize, and Quintana Roo (Mexico). Ranges from the area just east of Río Montagua to the area just north of Laguna Bacala on the Yucatán Peninsula. Includes (1) upper Río San Ramón of the Río Lacantun drainage, (2) Río Chajmaic of the Río de la Pasion drainage, (3) Río Delores of the Río Salinas drainage, (4) Río Chiain and Río Candelaria Yalicar within the Candelaria Valley and the Río Sachica of the Río Salinas drainage, (5) three basins lying between the Candelaria Valley and the Río Polochic drainages, (6) Río Sachica of the Río Salinas drainage, and (7) several basins associated with the Río de la Pasión, Río Sastun, and Río Polochic drainages. About half of the 24 fish species representing 13 genera and 9 families are endemic to the ecoregion.

32. Central American Karst Highlands--isolated upland and intermontane basins of northern Guatemala and neighboring Chiapas, Mexico. These basins, situated in a region of karst topography, have subterranean outlets.

33. Honduran/Nicaraguan Highlands--encompasses the Central American plateau, extending from central Nicaragua to the border of Honduras and Guatemala. Starting from the town of Acoyapa, Nicaragua northwest along the Atlantic Pacific drainage divide to the Guatemala-Honduras border (near Ocotepeque). Runs north along the watershed divide adjacent to Guatemala-Honduras border to San Pedro Sula. From San Pedro Sula, runs east to Nicaragua border at 200 m elevation. Runs south from Nicaragua-Honduras border at elevations greater than 200 m to La Batea, Nicaragua.

34. Lake Nicaragua--inland small rivers, lowlands, and associated uplands surrounding Lake Managua and Lake Nicaragua, including the Río San Juan, downstream to the rapids at Castillo de la Concepción.

Isthmus Atlantic Complex
35. Isthmus Atlantic--extends from the Caribbean Sea at Cabo Tiburon, southwest to Serrania de Darien mountain range, northwest to Cordillera de San Blas, southwest toward Bahia de Panama, just west of Río Chepo drainage. The western boundary follows the mid-isthmus Atlantic-Pacific divide northwest along the Atlantic Pacific divide to the Gulfo de Mosquitos.

Isthmus Pacific Complex
36. Isthmus Pacific--from just west of the Río Chepo drainage, the complex runs northeast to the Atlantic-Pacific drainage divide. It follows the divide west and northwest through the Cordillera de Guanacaste, and midway through the western shore of Lake Nicaragua to the level of the town of Rivas, and then to the Pacific.

Bahama Archipelago Complex
37. Bahamas--low-lying, carbonate, largely dry islands lacking fluvial systems. Freshwater present as small ponds in depression in limestone or where groundwater reaches the surface. Includes the Bahamas, as well as the Turks and Caicos Islands.

Western Insular Caribbean Complex
These large West Indian islands are characterized by high mountains, well-developed fluvial systems with steep profile, and well-developed flood plains with freshwater swamps and marshes. The complex covers the greater Antillean islands of Cuba, Hispaniola, and Jamaica. The smaller Cayman Islands and Florida Keys are included for biogeographic reasons.

38. Cuba--covers the Greater Antillean island of Cuba. Well-developed fluvial systems with floodplains are found largely on the southern part of the island. Freshwater swamps and marshes are extensive, with some freshwater lakes. Freshwater and brackish lagoons are associated with coastal regions.

39. Hispaniola--covers the Greater Antillean Island of Hispaniola (Haiti and the Dominican Republic). Well-developed fluvial systems drain mountains and plateaus, with some floodplain development supporting freshwater swamps and marshes.

40. Jamaica--includes the Greater Antillean Island of Jamaica. Well-developed fluvial systems drain steep mountains. Extensive floodplain development found on the southern part of the island, with freshwater swamps and marshes. Some upland palustrine systems present.

41. Cayman Islands--covers Grand Cayman Island, Little Cayman Island, and Cayman Brac. Low, dry limestone islands lacking fluvial systems. Minor freshwater wetlands present as ponds and ground-water seeps with associated marshes.

42. Florida Keys--includes the Florida Keys islands located south of peninsular Florida, bordered by Florida Bay to the north, the Gulf of Mexico to the west, and the Florida Straits to the east. Carbonate islands with widely scattered shallow pan, surface water ponds grading into brackish water mangrove habitat.

Eastern Insular Caribbean Complex
These small West Indian islands are characterized by mountains with small fluvial systems with steep profile and minor flood plains. The complex includes some low, dry islands without rivers or streams and small freshwater wetlands, consisting of ponds and floodwater basins. The complex also includes the Greater Antillean island of Puerto Rico with associated Virgin Islands, the lesser Antilles, and Tobago. (Puerto Rico is included for biogeographical reasons.)

Status report on Caribbean riverine systems and coarse-scale assessment of conservation priorities (prepared by Mary Alkins-Koo)

The Caribbean region supports a range of insular conditions with varying freshwater resources. This ranges from small arid islands (Antigua, Curaçao) to large islands with abundant freshwater resources (Trinidad and most of the Greater Antilles). Therefore, the distribution of freshwater resources is not equitable from one island to the next, and hydrological characteristics of these rivers vary. In most cases, the rivers are small and torrential with steep slopes owing to the topography of the islands, particularly in the Lesser Antilles where coastal plains are minimal. This is quite different in the Greater Antilles and Trinidad, where typically small Neotropical lowland riverine systems with associated floodplains exist.

The knowledge of the aquatic fauna and flora is not strongly supported, with published information being mostly of a taxonomic nature and scattered throughout the systematic literature. Some major studies include the Cuban-Romanian expedition, the University of Amsterdam expedition, and the Bredin-Archbold-Smithsonian survey of Dominica. Ecological studies include Harrison and Rankin's studies of St. Vincent and St. Lucia, Boon's studies in Jamaica and continuing today, Allen's work in Puerto Rico and Alkins-Koo's in Trinidad. The knowledge of large aquatic organisms (fish and prawns) is much further ahead than that for aquatic insects or lower invertebrates. Nevertheless, it is possible to make some generalizations. Biodiversity is relatively high, presumably due to the complex geological history of the islands and close relationships with faunas of North, Central and South America (for example, approximately 300 species of caddis flies are described for the insular Caribbean). The fauna includes species with wide distribution ranges (such as most fish and prawns), as well as those with limited distributions or even those endemic to certain islands (some caddis flies).

Human impacts on rivers vary widely, ranging from extreme deforestation of watersheds in Haiti to regulation by dam construction in Jamaica and Trinidad and watershed alteration by agriculture in most islands. Impacts of these activities on riverine systems are not well documented and are only superficially referred to in recently published reports, such as CCA/Island Resources Foundation series on Environmental Profiles of the Lesser Antillean Islands. Forest protection policies also vary widely, from well-supported efforts in Puerto Rico, Dominica, and St. Lucia, to a somewhat lesser effort in Trinidad, to virtually non-existent policies in Haiti.

Conservation priorities include the following:

(1) Maintenance of the integrity of watersheds to ensure regular supplies of good quality water. Water supplies are becoming more erratic due to deforestation in many islands, as well as water quality deterioration through pollution. This factor, of course, depends primarily on population and land development policies.

(2) Provision of resources for the establishment of a continuous monitoring protocol for both hydrological data and water quality. Infrastructure for hydrological data collection is sorely needed in many of the islands and continuous decimation of already limited facilities by hurricanes and flood

damage makes for a chronically deteriorating situation. The Caribbean Environmental Health Institute (CEHI) was empowered to collect data on pesticides in river waters, but no actual data exist due to lack of properly functioning equipment. The protocols for a low-technology, low-cost biomonitoring program are currently being developed at CEHI; it is necessary that this is accepted and established by Caribbean islands.

(3) Inventory of aquatic biodiversity and freshwater habitats. At the present time, there is much concentration on the unique terrestrial Caribbean fauna (especially birds) and its management. An inventory needs to be initiated on the freshwater fauna and habitats. Much of this will simply require collation of existing scattered data, although some field surveys of habitats will be necessary. Until these data are gathered, it is not possible to state conclusively whether specific habitat protection is necessary to support endemic or unique species in some groups (for example, waterfalls).

43. Puerto Rico and Virgin Islands--cover the Greater Antillean island of Puerto Rico, U.S. Virgin Islands, and British Virgin Islands. Puerto Rico has well-developed fluvial systems draining high mountains and some floodplain development. Freshwater swamps and marshes are present. The Virgin Islands have small river systems draining steep mountains with minor floodplain development. Small freshwater wetlands are present, largely at blocked stream mouths.

44. Windward and Leeward Islands--cover the islands of the Lesser Antilles, including Barbados and Tobago. Mostly small mountain stream systems with steep profile and minimal floodplain development. Small freshwater marshes and some swamp forest at river mouths; some upland lakes and palustrine systems are found. Some low, dry, carbonate islands are included, without fluvial systems, such as Anegada and Barbuda, which have only small freshwater ponds, but are biogeographically part of this ecoregion.

II. THE ANDES

This region encompasses the mountain ranges of the high Andes and adjoining mountainous regions, from 38°S (approximately where the Andes begin at over 3,000 m and the Bío Bío River) to the Darién Isthmus and the Sierra del Interior in Venezuela. Extends toward the east, reaching to the Piedmont (approximately 500 m elevation), including the Sierras de Córdoba in Argentina. To the west, extends to the Pacific coast, including the coastal islands and the Galápagos archipelago. For practical reasons, the plains and valleys of northern Colombia and Venezuela have been included to the north.

Chocó Complex

45. Chocó-runs from the Machala zone to the stretch of Darién and Serranía de Abibe and from sea level to 500 m. Includes rivers, estuaries, floodplains, mangrove swamps, and other coastal wetlands, with high endemism and productivity.

South American Caribbean Complex

This complex extends from the interandean valleys of the Cauca and Magdalena rivers to the Colombian Caribbean coast. It is limited to the west by the highlands of Abibe and to the east by the Sierra Nevada of Santa Marta and the Highlands of Perijá. It includes a dry, tropical forest zone, dense human settlements, and intensive and extensive agricultural and fishing systems. Its rivers have numerous tributaries. Muddy systems are found in the lower parts. Species include Erythrina glauca, Leatia acuminata, Chauna chavaria, Prochilodus reticulatus, Iguana iguana, resident and migratory Anatidae, concentrations of Laridae, migratory Charadriidae and Scolopacidae.

46. Magdalena--extends from the northern boundary of the Cordillera Central to the natural boundary of the town of Altamira's valley. Contains disturbed natural wetlands and considerable extensions of artificial wetlands used primarily to grow rice and for fisheries. Savanna crossed by the riverbeds of the Sinú, San Jorge, Magdalena rivers and their tributaries. Inlets and bays with mangrove cover in different phases of degradation; coral reefs and hypersaline standing pools, principally in the central sector of Bolívar and the Atlántico within Colombia.

From the Cauca Valley, runs approximately 4º30'N toward the south, to the natural boundary of the valley in the area of Santander de Quilichao. Swamps and marshes reduced to less than 10% of the original surface area since the beginning of the century. The water level of the river is partially regulated by a dam.

47. Momposina Depression--Río Cesar-delimited by the system of swamps, marshes, and narrow channels formed in the confluence of the San Jorge, Cauca, Magdalena, and Cesar rivers. The seasonal floodplains merge toward the west with the Sinú River and its tributaries.

48. Ciénega Grande de Santa Marta--the old deltaic system of the Magdalena River, bounded on the west by the mouth of the same river and on the east by the Sierra Nevada de Santa Marta. Contains compound lakes, channels, swamps, and marshes with estuarine characteristics. Due to construction of a causeway, more than 80% of the original mangrove cover has disappeared because the hydrographic regime has been altered and salinity has increased.

49. Guajira Desert--extends from the Piedmont of the Sierra Nevada de Santa Marta along the length of the Guajira peninsula. Xerophytic and subxerophytic scrub and escasas springs of fresh water, the main one being the Ranchería River. Its wetlands, all coastal, consist of shallow bays, some covered with mangroves, coral reefs, and saltflats.

50. Maracaibo Basin--extends from the mountainous region of Perijá toward the east to the vicinity of the city of Puerto Cabello, limited to the south by the interior mountains. This subdivision is dominated and characterized by the vast Lago Maracaibo.

High Andean Complex

This is a zone of lakes, lagoons, peat bogs, saline lakes, and other wetlands from elevations of 3,500 to 6,000 m, with fragmented distribution between interandean valleys and eastern sloping valleys. For reasons of scale, not all of the semi-arid valleys or the humid, sloping interdigitates of this region are distinguished. Also included is a region of saline lakes with endorheic watersheds, including a segment in the Department of Arequipa-Moquegua (volcanic zone of southern Peru and northern Chile). The central zone includes Coipasa, Uyuni, Atacama, Hombre Muerto, Olaroz and others at elevations above 3,500 m. Species include brackish bofedales.

Significant geographic differentiation within taxa is due to isolation, past migrations across a system of lakes, and climatic fluctuations. Species include birds (Larus serranus, Rollandia spp., Fulica cornuta, Chloëphaga melanoptera, Phoenicopterus, Phoenicoparrus), crustaceans (Leptestheria endemic spp.) insects, plants (Isolates, Zannichellia andina, Chara, Potamogeton, Myriophyllum, Distichia, Oxychloë); amphibians (Bufo, Telmatobius); and fish in rivers (Trichomycteridae, Trichomycterus, Orestias). Apart from an elevated regional endemicity (including, in some cases, the region of Titicaca), fragmented insular distribution is an essential characteristic of this region. This leads to an elevated genetic diversification and a dynamic of migrations and recolonizations. The fluctuating level of many lakes is useful for the birds to position themselves in the most productive lakes, migrating to other lakes throughout the year and according to annual fluctuations. It also serves as an important corridor and stopover for birds migrating from the northern hemisphere.

Human impact is most notable in extensive cattle-raising, subsistence and sport hunting and hunting for skins, mining leading to contamination and the death of lakes and rivers, fire, soil erosion, and hydroelectric dams. Introduction of trout is decreasing populations of native amphibians, fish and invertebrates (probably the most insidious and serious threat).

51. Páramos--wetlands páramos of Peru, Ecuador, Colombia, and Venezuela are widely distributed throughout this region. The southern limit is north of Peru in Cajamarca (Province of Jaen and San Ignacio) around 6ºS. Freshwater lakes occur here, although they are sometimes acidic and surrounded by peat bogs.

52. Peru High Andean Complex--extends from the Blanca mountain range and the Department of La Libertad to the north; to the south, extends to Lake Titicaca and the ecoregion of Los Salares. Penetrates into Bolivia to the Quimsa-

Cruz mountain range. Toward the north is Lake Junin, noted for the endemic grebe, Podiceps taczanowskii, and Orestias fish. Glacier lakes (many still connected to active or recently active glaciers) and poorly developed bogs occur.

53. Bolivian High Andean Complex--divided into two geographic units: (1) Arequipa-Moquegua and (2) Salares Centrales in Bolivia, Argentina, and Chile. Extends north and east of La Paz to the Quimsa-Cruz mountain range, including the Tunari and Cochabamba mountain ranges, until the Bermejo river in Tarija. Glacier lakes, bogs, and streams occur. Contains salares (and its dry, high-plateau watersheds) of large saline lakes with endorheic watersheds and an island in Arequipa-Moquegua (volcanic zone of southern Peru) and in the province of Catamarca (Sierras Pampeanas of Argentina). Central zone includes Coipasa, Uyuni, Atacama, Hombre Muerto, Olaroz and others generally above 3,500 m. Characterized by the saline lakes and arid climate. Includes brackish bofedales, as well as flamingos, microcrustaceans, and diatoms. Although less diverse, the long-isolated salares harbor unique species with unusual adaptations.

Human activities that threaten biodiversity in the region include exploitation of minerals (borates and salts), associated contamination, livestock grazing and watering, sport and bird hunting, and egg collection. The lower-area human population creates relatively less pressure, but these ecosystems are fragile with low productivity, making them highly sensitive.

54. Arid Puna--includes salares of large saline lakes with closed-basin watersheds. Region can be divided into two geographic units:
(1) Arequipa-Moquegua and
(2) Salares Centrales in Bolivia, Argentina, and Chile.
The central zone includes large salares (e.g., Coipasa, Uyuni, Atacama, Mombre Muerto, and Olaroz) generally above 3,500 m. There are many brackish lakes from arid climates or with freshwater and glacier morphology at more than 4,000 m, including the highest lakes in the world (e.g., Ojos del Salado, Pissis, Bonete, Vilama, Parinacota, Colorada-Eduardo Avaroa National Faunal Reserve, Chalviri, and Hedionda). Also includes brackish lakes with lime-argillaceous bottoms, surrounded by areas of little slope, alluvials, and somewhat developed phosphate swamps. Rich avian fauna compared to the pampean sierras and sub-andes. Contains two endemic flamingos (Phoenicoparrus andinus and P. jamesi), the horned coot (Fulica cornuta), and three other endemic coot species.

Human activities that threaten biodiversity include exploitation of minerals (borates and salts) and associated contamination, livestock grazing, trampling of riparian and wetland areas, and water drawoffs, sport and bird hunting, and egg collection. These are extremely fragile ecosystems, and their low productivity makes them highly sensitive to disturbance.

55. Subandean Pampas--covers Pampean sierras and subandes separated from the main Andean range: Famatina, Velazco, Ambato, Anconquija, Cumbres Calchaquíes, Zenta, and Santa Victoria. Includes freshwater lakes and rivers, occasionally with argillaceous or rocky bottoms. Contains seasonal lagoons with microcrustacean fauna, insects and ephemerid plants, large swamps with their own fauna and flora, and semi-seasonal and migratory avian fauna.

56. South Andean Yungas--description not available.

Inter-Andean Dry Valleys Complex
57. Inter-Andean Dry Valleys--includes inter-andean valleys of Colombia, Ecuador, Peru, Bolivia, and northern Argentina. Lower than the high Andes (elevation less than 3,500 m), but drier than the eastern slope (less than 700 mm annual rainfall). Insular distribution alternates with high-andean and eastern slope. For reasons of scale, map does not include all of the dry valleys. Examples include Colombia (Patía Valley, Cañón del Chicamocha), Ecuador (Mira River), Peru (Mantaro, Marañón), Bolivia (Cochabamba, Vallegrande, Sucre, Tarija), Argentina (Calchaquíes valleys, Humahuaca). Includes streams and rapid rivers originating in the high Andes and seasonal rivers. Contains few lakes. Impacts of a high-level of human settlement include extensive cattle-raising, deforestation, fire, agriculture, and soil erosion. Low rainfall and long droughts contribute to erosion, sedimentation of lakes and lagoons, and destruction of

riverbeds.

North Andean Montane Complex

This region extends from the Andes from northern Venezuela, Colombia, and Ecuador (from above 500-800 m elevation) up to the High Andean ecoregion (about 3,500 m elevation). It runs from Venezuela (Sierra del Interior) to the Huancabamba Basin and to the south, following the eastern slope in Peru, Bolivia, and Argentina to Córdoba and La Rioja. The complex is characterized by strong grades, abundant freshwater rivers and streams, tectonic lakes, and a high rate of precipitation with evergreen or semi-deciduous forests. Interandean valleys and high Andean terrain alternate. Examples include Yala lakes, Tesoro Lake, Amboró Sierra, and lakes in the Amazonas Department. Some characteristic taxa include Merganetta, Cinclus schulzii and C. leucocephalus, Telmatobius, Melanophryniscus, Aegla, Trichomycteridae, Astroblepidae, Ephemeroptera, and Podostemonaceae.

Because of its steep slopes, it is a region relatively less inhabited, but with recent population pressure, increasing numbers of roads are being opened, mountain sides stripped, and crops planted on steep slopes. Extensive cattle-raising is causing unprecedented erosion. There is also subsistence and sport hunting. Hydroelectric dams create a serious problem. Introduction of trout seriously threatens the amphibian, fish, and invertebrate populations.

58. North Andean Montane--covers mountain forests of Ecuador, Colombia, and Venezuela, extending from the Huancabamba Basin to Venezuela.

59. Humid Andean Yungas--covers warm, wet valleys of Bolivia and Peru, extending from Amboró to the Huancabamba Basin. Includes freshwater streams in mossy cloud forests and some tectonic lakes.

60. Chuquisaca and Tarija Yungas--includes warm valleys of Chuquisaca and Tarija and is characterized by rainforests (summer) and an extended dry season.

61. Salta and Tucumán Yungas--covers valley forests of Tucumán and Salta, and experiences a long, dry season. Freshwater mountain streams and shallow tectonic lakes serve as stopover for migrating birds.

62. Sierras de Córdoba--includes the Sierras de Córdoba, characterized by mountain pastureland, with small, freshwater streams.

Puyango-Tumbes Complex

63. Puyango-Tumbes--comprises a semi-arid region between 7ºS to Machala (0-800 m elevation). High abundance of Nymphaceae and Alismataceae found in stationary bodies of water. Disjunctions of Marsilea vestita and Isoëtes panamensis. Composition of aquatic flora with Amazonian association, in spite of the separation created by the Andes. Contains mangrove swamps.

Atacama/Sechura Complex

64. Atacama/Sechura Deserts--extends from Copiapó to Peru 7ºS (0-1,000 m elevation). Includes rivers of irregular volume mainly fed from the high Andes or from aquifers.

Pacific Coastal Deserts Complex

65. Pacific Coastal Deserts--runs from Copiapó up to 7ºS beneath salares (3,500 m). Lower limit at 1,000 m. Includes rivers of irregular volume, with multi-annual fluctuations.

Lake Titicaca/Poopó Complex

Lake Titicaca is a tectonic lake of great depth and age; Poopó is shallower and not as ancient. Rivers and clearwater streams feed into the two large lakes.

An extraordinary radiation of the endemic fish genus Orestias has evolved in Lake Titicaca. Some distinctive genera and species include Telmatobius (endemic and endangered species), Orestias (endemic and endangered species, one extinct), Rollandia microptera (Podicipedidae, flightless, endemic, and endangered bird), Phonicopterus, and Phoenicoparrus (flamingos). Plants include many high-andean elements, with significant endemicity, including Isoetes saracochensis (endemic), and Schoenoplectus californicus (totora or cattails, widely used for cultural purposes).

The area is densely populated with ancient cultural utilization. Several human cultures are closely associated with Lake Titicaca (Urus). Intensive agriculture and cattle ranching leading to soil erosion and the movement of sediment to the rivers and lakes. Human and mining contamination occur, and fires alter surrounding vegetation. Other threats include salinization due to irrigation, introduction of trout and silverside leading to elimination of native species, and overfishing of Telmatobius and Orestias.

66. Lake Titicaca--hydrographical basin characterized by a deep, cold, oligotrophic lake that can be divided into more than one ecosystem, with endemism localized to certain portions. Lack of detailed knowledge impedes the realization of a clearly formed subdivision.

67. Lake Poopó--hydrographical watershed of the Poopó, characterized by a brackish, shallow lake that can dry up in exceptional years. Less diverse than Titicaca but more susceptible to degradation. Lake Ururu does not dry up.

Galápagos Complex

68. Galápagos--littoral zone with mangroves; arid zone; Scalesia zone; Miconia zone; high-elevation zone with ferns and Cyperaceae. Characterized by brackish lagoons, sandy and rocky coasts, and mangrove swamps. Few freshwater species occur. Fishing and tourism are major pressures.

Recommendations for Andean Region

General

o Promote the integrated management of watersheds
o Promote biological, hydrologic, and socioeconomic research in wetland regions
o Promote creation of Protected Areas from Multiple-Use Areas

Specific

o Initiate research on environmental impacts in Lake Ururu and to the south of Lake Poopó.
o Implement ways to mitigate mineral contamination in the wetlands of high-andean Peru.
o Establish protected areas in high-andean Bolivia.
o Implement regional investigations on the saline lakes of dry plateau.
o Promote establishment of protected areas in dry, inter-andean valleys.
o Implement recommendations of environmental impact study regarding dam construction in the mountain forests of Ecuador, Colombia, Venezuela, Bolivia, and Argentina.
o Monitor the watersheds of moist valleys of Peru and Bolivia.
o Complete basic research in Chuquisaca and Tarija Valleys.
o Control and monitor mineral contamination in the watershed of Salar de Atacama.
o Implement monitoring of watersheds and promote wetlands restoration in the coastal deserts of Peru and Chile.
o Complete water quality research and promote activities to restore the mangroves in Puyango-Túmbez.
o Create coastal protected areas, inventory bioaquatic resources, promote sustainable development projects for mangrove swamps, and promote water treatments from estuaries in Chocó.
o Promote restoration of wetlands in the high valley of the Cauca River.
o Promote creation of a special management area in the Momposina Basin.
o Support restoration programs of Ciénega Grande de Santa Marta.
o Strengthen conservation projects and investigations and implement a marine reserve in the Galápagos.

III. SOUTHERN CONE (CHILE)

Mediterranean Chile Complex

Ecoregions 69 (North Mediterranean Chile) and 70 (South Mediterranean Chile) have no summaries.

Juan Fernandez Islands Complex

Ecoregion 71 (Juan Fernandez Islands) has no summary.

Southern Chile Complex

Ecoregions 72 (Valdivian), 73 (Chiloe Island), 74 (Chonos Archipelago), and 75 (Magallanes/Ultima Esperanza) have no summaries.

Subantarctic Complex

Ecoregion 76 (Subantarctic) has no summary.

IV. ORINOCO, AMAZON, AND LA PLATA BASIN

Venezuelan Coast/Trinidad Complex

77. Venezuelan Coast/Trinidad--composed of short, coastal rivers that drain into the Caribbean Sea, including the rivers of Trinidad and the Margarita islands. Some aquatic habitats are marginal and ephemeral. Rivers are small in size and are characterized by clear waters. Trinidad has permanent rivers draining low mountain ranges. Some upland palustrine systems are present. Well-developed floodplains with extensive freshwater swamp forests and marshes occur. There are biogeographic affinities with the Orinoco region of northern coastal Venezuela. Principal threats are urban factors (domestic pollution). Some rivers are affected by agricultural practices.

Rivers harbor some unique coastal types of species that were well distributed in the past. Some are of great biological importance; for example, the glandulocaudine fishes (Gephyrocharax and Corinopoma). Undisturbed and unpolluted rivers are used for domestic and recreational purposes.

Region still has some locally important unmodified areas. Some areas (national parks) are already protected by Venezuelan laws. Studies are still needed to assist in conserving other areas. Development of a sustainable use program for freshwater swamp fisheries (finfish, conch, crustaceans) in the Nariva swamp is needed.

Human utility. Rivers have been impacted heavily by traditional human activities, such as city sewage disposal and irrigation of field crops. Water uses are sustainable or unsustainable, depending on the proximity to cities. In Trinidad, the freshwater habitats support major fishing activities, cattle-grazing, hunting, and forest product harvesting. Some areas have been reclaimed for agriculture, particularly rice culture, and there is some fish-pond farming. These activities threaten several swamp areas, but conservation groups are working on the problems.

Llanos Complex

78. Llanos--covers all savanna grasslands in the northwestern portion of the Orinoco River Basin of Venezuela and Colombia. Includes the Apure, Arauca, Meta, and Guaviare river systems in the southwest to the Zuata/Caris Basin in the northeast. Savannas range from dry ones at higher elevations to wet, flooded ones at lower elevations. The low-altitude llanos are often inundated for six-to-eight months per year. This ecoregion is delimited in the south by the Río Guaviare and extends to eastern Venezuela as far as the Atlantic-draining Morichales of the San Juan and Morichal Largo basins to the Suata and Caris rivers. Geologically, this is the most recently formed area of South America. It includes all habitats from 15 m up to 100 m elevation in the Piedmont of the Andes.

This area represents a large savanna ecosystem and includes several important river watersheds (Apure, Arauca, Meta, Guaviare). The region is a mosaic of terrestrial and aquatic habitats, such as flooded savannas, inundated forests, lagoons, and creeks that harbor a great diversity of aquatic elements and support large fisheries. The morichales, flooded savannas, and inundated forests are of great biological importance as nurseries and areas of high diversity and endemism. Risks or threats to natural habitats are due to conversion of these habitats to promote aquaculture, cattle-raising, draining, damming, channelization, and urban development. Human Utility: Rivers of the Llanos have traditionally been used for transportation, fisheries, recreation, and commercial purposes. Sustainable uses include dammed headwaters for domestic and agricultural purposes. Timber harvesting has occurred for hundreds of years, as well as intensive hunting of water birds for ornamental purposes in European countries. Water mammals have been heavily hunted. Their disappearance is also associated with changes in habitat. The Orinoco caiman is listed as an endangered species. Unsustainable uses of water include the draining or "sanitation" of land, damming, and channelization. In addition, sewage pollution is heavy in the northern waters of the region and in the river headwaters.

Recommendations: Activities should be directed toward the recuperation of damaged and impacted areas (habitats) and of species, as well as the conservation of natural (pristine) areas. Morichales and flooded savannas and riparian forests should have high priority due to their high biodiversity, biological importance for aquatic organisms, and high productivity for the maintenance of human populations.

Guiana/Orinoco Complex

This large region of approximately 1,500,000 km2 extends from the eastern-flowing Morichales north of the Orinoco River (approximately 64ºW latitude, 10ºN longitude) to the drainage basins on the south side of the lower Orinoco and includes all drainages of the upper Orinoco, except the Casiquiare and Negro rivers. The complex also includes all of the Atlantic drainages of the Guiana Shield southeast of the Orinoco River mouth from the Río Cuyuni to the Oyapock of French Guiana.

The region covers highland and lowland areas of the Guiana Shield and includes large rivers of the Orinoco Basin, such as the Caroni, Atabapo, Ventauri, Sipapo-Autana, and Cunucunuma in Venezuela, as well as the Essequito, Maroni, and Oyapock in the Guianas. All of these rivers drain the Guiana Shield. Aquatic habitats include flooded forests, rapids, cataracts, lakes, lagoons, morichales, savannas, blackwater creeks, inselbergs with isolated wet areas, and tepuis. The minerals laterite and bauxite, which are common components of Guiana Shield rock formations, affect chemical composition of many rivers. Threats to this ecoregion include deforestation (logging and mining) and hydroelectric dams. Also, major river diversions have been engineered for several rivers, including the Río Caura. The Caura River Basin is the Earth's largest remaining intact, tropical watershed, harboring extraordinary freshwater biodiversity (O. Huber 1997).

Human Utility: The rivers of this ecoregion have traditionally been used for local and commercial transportation, fisheries, and cultural (indigenous) purposes. Hunting and water use are local and sustainable. Mining and deforestation of riparian forest represent a threat. Timber harvest for commercial purpose has recently been introduced.

Recommendations: Despite ecological impact and degradation of some areas (for example, the Cuyuni, Essequibo, Omai, and Caroni rivers) due to deforestation, mining, petroleum extraction, and transportation, the region as a whole still has several pristine areas of global importance. Tepuis and rivers flowing from the central Guiana Shield (Caura, Essequibo, Ojapock, Maroni, Ventuari, Orinoco headwaters), as well as their flooded forests and savannas (for example, the Rupununi), should be conserved. Also, effort should be directed toward promoting studies of the ecosystem dynamics of the Caura River Basin. Those studies should also produce plans for better management of the area and conservation of this river, which, in addition to its outstanding biodiversity value, is culturally important to local indigenous human communities.

Other areas, such as the Morichales in Venezuela, the Rupununi savannas in Guiana, and the head-waters of several rivers of the Guiana Shield, must be preserved due to their great importance to the maintenance of aquatic biodiversity, as well as to humans. For regions with high levels of human activities such as mining, deforestation, and petroleum exploitation, special conservation programs must be promoted. These should focus on recuperation of impacted and damaged areas, better management of the hydrology of the basins, and control of the development of mining and timber harvesting.

79. Eastern Morichal--includes the eastern flowing Morichales that enters either the Orinoco Delta or the Atlantic Ocean independently of the Río Orinoco. Includes the Río San Juan and the Morichal Largo drainages, which are

primarily clear to blackwater morichal (aguajal, murichizal) habitats, usually with sandy bottoms and rooted or floating aquatic plants. This large area contains savanna-type and special aquatic habitats characterized by vegetation (aquatic/terrestrial) dominated by a single genus of palm tree (Mauritia sp.). This area is usually a refuge for terrestrial and aquatic animals, particularly during the dry season.

80. Orinoco Delta--includes the Orinoco Delta below the mouth of the Río Caroni at Ciudad Guayana. This is typical delta habitat and includes big river channels and shallow muddy marshes, as well as riverlets with emergent aquatic vegetation. Represents a large area of habitats dominated by the influence of estuarine elements, including lagoons, channels, and caños (narrow channels) influenced by tides.

81. Southern Orinoco--contains a river basin that flows to the Atlantic independently of the Río Orinoco. Comprises tributaries to the Orinoco that drain off the Guiana Shield and the main channel of the Orinoco, principally from the south as far as the Río Caroni in the east. This region does not include the Casiquiare Canal or the Río Negro. These habitats are varied and include white, green, clear, and blackwater habitats, small forest caños, big rivers, lagoons, rapids, and waterfalls. The river bottoms are sandy to muddy. Tepuis are of global importance due to their uniqueness and high levels of endemism and relict taxa in aquatic and terrestrial organisms.

82. Guiana Watershed--contains the river basins that flow independently to the Atlantic from the Río Cuyuni in the northwest to the basin of the Oyapock River in the south. The headwaters of all these river systems are located on the northern slope of the Guiana Shield. Habitats include several rivers that have headwaters in the Guiana Shield. Cataracts, rapids, and riparian flooded forests are common. Also, patches of flooded savannas are of great biological importance.

Amazon Complex
This complex contains the largest river basin in the world, encompassing more than four million km2. It includes all possible types of aquatic habitats (whitewater, clearwater, and blackwater rivers; small forest streams; natural and manmade lakes; deep channels and floodplains; igapós and varzeas; rapids and waterfalls). The basin itself is a sedimentary area located between the Pre-Cambrian Central Brazilian Shield in the south and the Guiana Shield in the north. The headwaters forming the Marañon-Solimoes-Amazonas river system come from the Andes mountains, located at the western limits of the basin. The main tributaries are the following rivers: Japura, Putumayo, Huallaga, Javari, Tefe, Jurua, Negro, Madeira, Trombetas, Tapajos, Xingu, and Tocantins.

The Amazon Basin harbors the richest freshwater fish fauna in the world (more than 3,000 species) and a great diversity of other aquatic vertebrates, such as birds, reptiles, mammals, and amphibians, as well as numerous invertebrate species. Also, the aquatic vegetation is rich, especially the macrophytes, which make the floodplain areas highly productive.

Human Utility: This ecoregion is one of the largest and most diverse biomes in the world. Large areas are being threatened by such activities as overfishing, agriculture, deforestation, and mining. The most seriously affected areas are the floodplains along the channels of large rivers and the headwaters of the main tributaries.

Several native communities occur along the eastern slope of the Andes, where the waterbodies are used as a sustainable resource and for fishing. At altitudes below 500 m, the principal uses of waterways and riparian areas are transportation, fisheries, timber harvesting, hunting, and fruit harvesting. The entire ecoregion is important for human travel and commercial transportation. Resources are used by riverine communities in important and sustainable ways, including fishing, timber and plant harvesting, and hunting. However, some technologically advanced activities make use of many resources unsustainable. These activities include overfishing of food and ornamental fishes, extensive logging and deforestation, agriculture, overhunting, and extensive mining in the headwaters. However, there is potential to use water sustainably for industry and hydroelectric power.

Recommendations: Actions should be directed toward avoiding uncontrolled timber extraction, human settlement, agricultural projects along floodplains, illegal mining, and other activities that cause loss of water quality and habitat damage. Some areas that need conservation programs, particularly those located in regions without protected areas, currently are low priority. These include the drainage area of the Río Morona and Río Pataza, which has a diverse fish fauna representative of the Amazon headwaters, and the upper portion of the Río Ucayali system, which includes many rivers and the largest, oldest flooded blackwater lagoon (the Inurea) in the Peruvian Amazon. This savanna has a highly diverse and endemic fish fauna.

83. Amazon Delta--extends along the coast from Cabo Cassipore to Belem and inland to Gurupa and includes the Río Araguari and the lower part of the Río Tocantins, as well as the Marajo Island complex. Habitats include lowland rivers, deep channels, small forest streams, lakes, waterfalls, rapids, floodplains, and whitewater and clearwater rivers.

84. Amazon Main Channel--contains the main channel of the Amazon River from above the delta to Iquitos in Peru and includes the floodplain areas along the river. Habitats include lowland whitewater rivers, deep channels, lakes, and floodplains.

85. Northern Amazon Shield Tributaries--extends from the Amazon Delta up to, but not including, the Río Negro drainage. Habitats include lowland rivers and floodplains, waterfalls, rapids, deep channels, lakes, small clearwater and blackwater forest streams, and blackwater and clearwater rivers.

86. Río Negro--includes the Río Negro and its main tributaries (Río Branco, Casiquiare, and Uaupes). Habitats include lowland blackwater rivers, deep channels, floodplains, rapids, waterfalls, clearwater rivers, lakes, and small clearwater and blackwater forest streams.

87. Upper Amazon Piedmont--includes drainages at 400-1,000 m elevations and cuts across the following rivers: Napo, Pastaza (Ecuador-Peru); Huallaga, Ucayali, and Madre de Dios (Peru); and Beni and Mamoré (Bolivia). Includes hundreds of small rivers and streams with torrents of fast-moving, cold waters. Several reophilic species such as catfishes (Astroblepus, Trichomycterus, and Chaetostoma) or characins (Creagrutus, Acrobrycon, and Hemibrycon) live in the upper portion. In the lower portion (below 600 m), the number, size, and type of waterbodies increase, as does the number of species. In addition, the seasonal changes of the region facilitate the maintenance of a diversified fish fauna. Important functions of this ecoregion include the maintenance of a water reserve that helps regulate seasonal hydrological levels; the maintenance of high levels of biological diversity, in terms of both numbers of species (e.g., fishes) and levels of endemism. Principal threats to this system include loss of habitats and species related to human activities, including deforestation, mining, oil exploration, and water pollution.

88. Western Amazon Lowlands--restricted to habitats below 400 m elevation and includes the following rivers: Japura, Putumayo, Javari, Tefe, Jurua, and Madeira. Habitats include whitewater rivers, deep channels, lakes, floodplains, and small forest streams.

89. Central Brazilian Shield Tributaries--includes the Tapajos, Xingu, and Guapore river basins. Habitats include clearwater rivers, deep channels, lakes, waterfalls, rapids, small forest streams, and floodplains. The Chiquitano Shield is composed of seasonally dry, semi-humid forest with rapids and clearwater rivers, whereas the Huanchaca plateau is composed of savanna and gallery forest with clear-water mountain streams, large waterfalls and endemic plants (Podostemonaceae).

90. Tocantins-Araguaia--includes Tocantins and Araguaia river basins. Habitats include clearwater rivers, deep channels, lakes, manmade lakes, waterfalls, rapids, small forest streams, and floodplains.

Northeast Atlantic Complex

91. Maranhão--extends from the Amazon Delta and lower Tocantins to the Río Parnaíba Basin, and includes the eastern part of Para state and the states of Maranhão and Piaui. Drained by the coastal rivers running northward to the Atlantic Ocean and to Bahia de Marajo. Principal rivers are the Capim, Gurupi, Mearim, and Paranaíba. Some tributaries of the Parnaíba River are temporary.

Aquatic fauna is essentially the same as that of the Amazon, but not as diverse. Local faunal components, particularly in the Capim and Mearim rivers, characterize the area as relatively endemic.

Human Utility: The ecoregion is used for transportation, sport fishing, tourism, and, in larger rivers, commerce. Some rivers are used for religious celebrations. Major rivers sustain intensive fishing, irrigation, and human utilization. However, other rivers, such as the Paranaíba, are overfished. Aquatic habitats are impacted by sewage and pollution in the vicinity of large cities, and agricultural uses have impacted many riparian communities.

Recommendations: Conservation actions should be directed toward avoiding damage to the environment caused by agricultural activities, cattle-raising, mining, and pollution, particularly in the vicinity of large cities.

Mata-Atlântica Complex

This complex extends from the state of Piaui down to the northern part of the state of Rio Grande do Sul. A series of small-to-large rivers and streams drain the forest into the Atlantic Ocean. These waterways contain a diverse and endemic fish fauna. The main rivers (from north to south) are as follows: Jaguaribe, lower part of the São Francisco, Itapicuru, Pardo, Contas, Jequitinhonha, Doce, Paraíba, and Ribeira de Iguape.

Human Utility: Cultural uses of aquatic environments are moderate, but uses for transportation, recreation, and commerce are of low importance. Several traditional communities have sustainable fisheries, game harvesting, and timber and plant harvesting. Modern activities, such as fishing, water intake, logging, and plant resources are overexploiting the rivers. Sewage, pollution, riparian development for banana, eucalyptus, sugar cane farming, and cattle-ranching are also having negative impacts on this ecosystem.

Recommendations: The forest, which provides food and protection to fish, is now reduced to 10% of its original extension and represents one of the most threatened biomes in Brazil. For large cities, these aquatic environments represent important water supplies for human consumption. Actions should be directed toward preserving the remaining forest and associated watersheds.

92. Northeast Mata-Atlântica--contains small- to medium-size rivers and small streams. The principal river systems are as follows: Piranha-Açu, Mossoro, Potengi, Guiana, Jaboatao, Ipojuca, Mundau, Paraiba do Meio, Sergipe, lower São Francisco, Vaza Barris, Itapicuru, and Paraguacu. Some of the small rivers are temporary; larger rivers have a depauperate but endemic fish fauna. Lakes, ponds, and other lentic waterbodies are scarce. Other aquatic vertebrates and invertebrates are few in number.

93. Eastern Mata-Atlântica--includes the following river systems (from north to south): Contas, Jequitinhonha, Jacurucu, São Mateus, and Doce. Contains larger rivers than does the northeast ecoregion and, consequently, a more numerous and diverse fish fuana. Endemism is also high.

94. Southeastern Mata-Atlântica--includes the Paraíba and Ribeira do Iguape river systems. These relatively large rivers facilitate the maintenance of large fish populations and smaller rivers and streams harbor a diversified vertebrate and invertebrate aquatic fauna.

São Francisco Complex

This complex is perhaps the most important river in Brazil. It extends from Serra de Canastra in Minas Gerais to the Atlantic Ocean and empties to the sea between the states of Sergipe and Alagoas. The area crosses three main ecological domains: Cerrado, Caatinga, and Atlantic forest. Principal tributaries are as follows (from south to north): Paraopeba, Velhas, Paracatu, Verde Grande, Carinhana, and Corrente. The complex is characterized by a diversified and highly endemic fish fauna distributed through lakes, rivers, small streams, and other aquatic habitats. Other aquatic vertebrates and invertebrates are less abundant because of deforestation and local pollution.

Human Utility: Middle and lower portions of the river are used extensively for transportation and commerce. The entire ecoregion is used for tourism and sport fishing. The river is also used in religious and popular celebrations. It supplies water for such sustainable uses as irrigation, recreation, hydroelectric power, and commercial fisheries. Unsustainable activities include commercial overfishing and deforestation of riparian habitats for agriculture. Other negative human impacts include sewage from large urban centers and pesticide runoff from farms and ranches. Mining activities are also extensive at higher elevations and in river headwaters.

Recommendations: The river has been continuously degraded by pollution from pesticides and sewage, mining in the headwaters, damming, and deforestation. Actions to prevent further damage to the river should be directed toward controlling pollution, providing sustainable fisheries, and promoting recovery of the original riparian vegetation. Any plans to divert the river into other areas for irrigation and other types of water uses will drastically affect the already precarious ecological balance within the basin.

95. Caatinga--includes the Río São Francisco from the Paolo Alfonso Falls to the Sobradinho Dam. The São Francisco runs through dry land characterized by vegetation typical of this habitat type (e.g., cacti and shrubs). Low precipitation creates marginal areas arid during the dry season. Floodplains are reduced, and lakes, small ponds, and streams are scarce. Fish fauna is typically endemic and relatively diverse. Other aquatic vertebrates are few and scattered throughout the basin.

96. Cerrado--extends from the Sobradinho Dam to the headwaters of the Río São Francisco. In general, the aquatic fauna is as diverse as that of the Caatinga ecoregion, but is richer in species diversity because ponds and streams along the edges of the rivers provide additional varied habitats.

Upper Paraná Complex

97. Upper Paraná-includes parts of the states of Minas Gerais, Mato Grosso, and most of São Paulo and Paraná. Limited in the south by the Iguacu and Sete Quedas waterfalls. Includes the upper part of the Río Paraná and its main tributaries: Grande, Turvo, Paranaíba, Tiete, Paranapanema, Ivai, and Iguaçu rivers. Fish fauna is rich (more than 300 species) and highly endemic. Other aquatic organisms, both vertebrates and invertebrates, are also abundant. Human Utility: Used extensively for transport of crops and supports sustainable sports and commercial fisheries. There is considerable, and apparently sustainable, water diversion for hydroelectric use. Unsustainable uses include irrigation in some areas and timber harvesting.

Recommendations: Agricultural activities have negatively affected the riparian forest and have indirectly caused pollution of rivers and streams through the use of pesticides. Sewage from several large- to medium-size cities has contributed to extensive pollution in most of the basin. Actions should be taken to better control further damage caused by these problems.

Beni Complex

98. Beni-located on a large plain between the Beni and Guaporé rivers at approximately 250 m altitude, with grassy and patchy forest vegetation. Includes drainages of the Beni, Mamoré, Madeira, and the lower part of the Guaporé (It'enez). Includes portions of the Beni, Mamoré, and Madeira river systems that are not in other subdivisions. Inundated savannas in the state of Beni predominate. These areas include shallow lakes (for example, Rogagua and Rogaguado), large rivers, extensive herbaceous systems (curichis) and seasonally inundated savannas, such as Campo San Ramon and Campo Hunchaca.

In terms of flora and fauna, there is a great diversity of fish, aquatic mammals, and aquatic reptiles. Fish fauna include food fishes and endemic species. Most conspicuous are several species of piranhas (Serrasalmus), pacu (Colossoma), and such catfish as surubi (Pseudoplatystoma). Aquatic mammals, including river dolphins (Inia), giant river otters (Pteronura brasiliensis), and capybara (Hydrochaeris hydrochaeris), are commonly found. Avifaunal representatives include ibises, herons, egrets, and ducks. Common reptiles include Caiman (Caiman yacare and Melanosuchus niger), and such turtles as Podocnemis unifilius and P. expansa. Aquatic vegetation is dominated by Cyperacea and floating, submerged plants, such as those in the genera Eichornia and Pontederia.

Human Utility: Area is important for indigenous peoples, such as the Chimanes, who use the forest in a highly sustainable fashion, principally for fishing and transportation. Farming and cattle-ranching are the major unsustainable uses.

Recommendations: More attention to development of conservation programs is needed between the Mamoré and Guaporé rivers. In addition, protected areas, such as the Beni Biological Reserve, need more financial support for management programs and research projects.

Paraguay-Paraná Complex
This complex extends from western central Brazil and southeastern Bolivia south to central Paraguay and northeastern Argentina. Its southern limit is the mouth of the Río Paraná. It is characterized by periodically flooded lowland areas. It includes the Paraguay River, lower portions of the Paraná and the Uruguay rivers, and all of their tributaries. Among the main rivers are the São Lourenço, Taquari, Bamburral, and Pilcomayo.

The region has more than 300 fish species and several large invertebrates, such as decapod crustaceans (crayfish) and mollusks. The fauna contains many Amazonian elements, even at the species level, and, in this respect, contrasts sharply with the remaining Paraná Basin, from which it is somewhat isolated by major waterfalls. The lake of the ItaipÝ dam covered the Sete Quedas waterfalls, allowing for the mixing of fish faunas from the high and middle Paraná. Large- to medium-size rivers, lakes, streams, and floodplains are abundant.

Human Utility: The region is important for transport of cargo and for tourism, especially in the Pantanal. The native Guator and Kadiveu peoples use the waterways for cultural purposes, and the Pantaneiro people maintain traditional fisheries. Sustainable uses include sport and commercial fishing and, in some areas of the lower Paraná, irrigation. Unsustainable uses include mining, agriculture, and cattle-raising, which in a number of basins, have degraded the environment to a large extent. Particularly fragile is the Pantanal, which has been threatened by road construction, a proposed waterway (the Hidrovía), mining, cattle-raising, and deforestation.

Recommendations: Such fragile areas as the Pantanal should be preserved at any cost because of their uniqueness. Policies should be initiated to prevent further damage caused by unregulated human activities. Policies concerning the use of certain areas for tourism should be well defined to avoid overfishing and habitat damage.

99. Pantanal--relatively flat area that covers more than 200,000 km2 and contains the headwaters of the Paraguay, Cuiabá, Taquarí, Miranda, and Apa rivers. Seasonal fluctuations of the water level create a complicated system of temporary pools and channels, which, together with permanent pools and ponds on high ground, contain rich aquatic fauna, including more than 300 species of fish. Many species are commercially important and are fished regularly to supply markets both within and outside the area. Birds are especially abundant. Reptiles, amphibians, mammals and aquatic invertebrates are major components of the aquatic fauna.

100. Lower Paraná--includes the lower part of the Río Paraguay from Río Apa down to the lower part of the Río Paraná below the Sete Quedas waterfalls. Also includes the Uruguay River Basin and all of its tributaries. The southern limit is the point where the lower Paraná empties into the Río de la Plata. Lotic, lentic, and other aquatic habitats harbor a rich fish fauna and a relatively diverse fauna of other vertebrates, as well as invertebrates.

Southern Atlantic Complex
This complex includes the Jacuí River Basin and smaller rivers and streams flowing into Lagoa dos Patos and Lagoa Mirim in Brazil and Uruguay. Principal rivers are the Jaguarao, Camaqua, and Jucui. Fish fauna is somewhat depauperate in comparison to the adjacent Uruguayan river system, but contains several endemic components. Coastal plain areas are characterized by lagoons and swamps bearing peculiar species, in contrast to the higher-elevation areas, where diversity is greater. Bird fauna is particularly rich, but other aquatic vertebrates and invertebrates are less diverse.

In the highland part of this ecoregion, the aquatic environments are affected mainly by agricultural activities and urbanization. In the coastal plain areas, the principal problems center on pollution of lagoons, swamps, and other water bodies, caused by pesticides, sewage, cattle-raising, and agricultural practices.

Human Utility: This ecoregion supports intensive transportation activities in the Lagoa dos Patos and the lower regions of large rivers. Commerce is principally for industrial and agricultural products. There are also popular and religious celebrations using the river. Aquatic resources support sustainable fisheries for subsistence fishermen, as well as use of water for industrial and hydroelectric purposes, consumption, and irrigation. In selected areas, bird hunting has caused problems. There are high levels of sewage and pollution near the larger cities, and pesticides in agricultural regions. Agricultural development of riparian areas has had a negative impact. Recommendations: Conservation policies should be directed toward protecting the relatively stable, remaining ecosystems. Special attention should be devoted to control the use of water resources, particularly with regard to irrigation practices.

101. Jacuí Highlands--includes the highlands of the Serra Geral, and the cristalin basement of the Serra do Mar, in the northern and central part of the state of Rio Grande do Sul (Brazil). The area is drained by four major river basins (Jacuí, Ibicú, Taquarí, and dos Sinos) and is characterized by grasslands and the Araucaria forest. Aquatic environments are usually oligotrophic, and habitats are mainly rivers, rapids, waterfalls, manmade lakes, small floodplains, and small streams. The region has a typical headwater fauna with a composition distinct from that of the adjacent Río Guaiba/lagunar system. There are many endemic species of fish and crustaceans (Aeglidae and Parastacidae). Fish and aquatic bird faunas are more depauperate than in the coastal plain ecoregion.

102. Lagoa dos Patos Coastal Plain--extends from the north of the state of Rio Grande do Sul (Brazil) to southeastern Uruguay, and includes small rivers draining directly into the Atlantic Ocean and their associated system of lagoons. Fish fauna has a recent origin (it is mainly inhabiting a lagunar system from the Quaternary Period). Many fish fauna are endemic, making this area distinct from adjacent ones. This region is especially important for aquatic birds; several migrating species from the Neartic Region use this area as a feeding site.

Chaco Complex

103. Chaco-arid region that includes the western tributaries of the Paraguay-Paraná rivers and is shared by Bolivia, Paraguay, and Argentina. Habitats include the seasonally flooded and monsoon plains and valleys bordering the Beni plain to the north; the Chiquitano region (Brazilian Shield) to the west; the Andean and sub-Andean Piedmont, Colorado River, and Sierras de Córdoba to the south; and the Paraguay-Paraná rivers and Buenos Aires pampas to the east. Fauna are similar to that of Beni, and include such fishes as pacu (Colossoma), surubí (Pseudoplatystoma), pirañas (Serrasalmus), sábalo (Prochilodus), and the lungfish (Lepidosiren paradoxa).

Although the Chaco and Beni have similar compositions with respect to the fish genera, species composition differs. Aquatic reptilian fauna is the same as that of Beni, but poorer. Differences between the Chaco and Beni ecoregions include the following: average precipitation is higher in the Beni; the upper Chaco is xerophytic; the lower Chaco is wetter than the Beni, and vegetation is denser and more diverse. Future work may support the idea that this ecoregion should be subdivided.

Human Utility: Human uses of the Chaco differ between the Chaco Húmedo (wet Chaco) and the Chaco Seco (dry Chaco). In the wet Chaco, native Guaraní tribes use the rivers as water resources, principally for transportation, fisheries, and the extraction of forest products. The Chaco Seco includes 60% of the ecoregion, where water is scarce. Here, the native Ayoreos practice hunting and farming activities.

Recommendations: Greater attention should be given to the conservation of the wet regions of the Chaco, which contains rich and diverse fish fauna, particularly in the Alto Paraná drainage area.

Pampas Complex

This complex covers the Eastern plains of Argentina between approximately 33º and 39ºS. Geologically, the Pampas is a large basin between the Andean mountain range and the Precambrian shield of Brazil, consisting of terrestrial and marine sediments from the Cretaceous and Tertiary periods, subsequently filled in by the pampean formation of the Quaternary. This ecoregion is noted for its thick stratum of loess and arenaceous sediment. The flora is dominated by plains grasses, with numerous herbaceous species. The vegetation is greatly altered by agriculture and cattle-raising. There are 109 species of mammals (12 exotic), 360 species of birds (6 exotic), 51 species of reptiles, 27 amphibians, and 185 species of freshwater fish (5 introduced).

The climate is temperate, with the average yearly temperature ranging between 13º and 17ºC. The amount of precipitation decreases toward the south and west from 1,035 mm to 623 mm. Periodic flooding submerges large areas, altering the morphology of the water bodies and allowing contact between aquatic creatures, which would otherwise remain separated.

Aquatic environments are numerous and diverse. In the province of Buenos Aires alone, there are 1,429 shallow lakes of maximum length equal to or greater than 500 m. Although rivers, small streams, lakes, and marshes are the most common, other types of aquatic habitats, such as swamps, exist.

At least 15 aquatic environments are recognized. Considering the lacustrian lowlands/watersheds, drainage areas, and geomorphologic characteristics, the wetlands of the complex can be organized into five ecoregions.

104. Parano--Platense Basin-in the Province of Buenos Aires, 28 shallow lakes (14 seasonal) have been registered. Some important lakes of southern Santa Fé should also be considered, particularly Laguna Melincué (8 km in length [12,000 ha]), whose waters turn brackish to salty in times of drought. Although it is the most industrialized and densely populated zone in the region, there is a wide range of biodiversity: 51 mammals (8 introduced, exotic species), 294 birds, 29 reptiles, and 24 amphibians. Seventy-two species of fish have been identified in the tributaries of the Río de la Plata and 146 species in the Río de la Plata itself.

105. Río Salado and Arroyo Vallimanca Basin--situated in the lowland plains, comprising the Samborombón River and the Salado River and its tributaries. Its area (excluding the Arroyo Vallimanca) covers approximately 80,000 km2 and, in general, is oligohaline to mesohaline. Within the lentic environments of this zone, 339 shallow lakes (125 temporary) have been registered of variable salinity. The most important habitats are a community designated as "cangrejales" around the Samborombón Bay, system of lagunas, "Encadenadas de Chascomús" (11,668 ha), and the riverbed of the Salado River (690 km in length).

106. Northwest Pampas Basins--does not possess its own drainage system and is the driest area in the region. The lotic environments are only represented by flat streams, generally impermanent, and some artificial drainage canals. The western boundary of this zone is inexact, and the little studied Amarga swampland (southeast of Córdoba), should perhaps be included in the region. Two hundred seventy lakes (241 temporary) have been registered. The most important group corresponds to the compound lagunas system, Las Tunas-El Hinojo (Trenque Lauquen).

107. Pampas Coastal Plains--includes the waterways of the Atlantic slope and several of the northeastern endorheic watersheds of Tandilia, which possess artificial drainage by means of canals to Samborombón Bay or the Atlantic Ocean. There are 695 lagunas (477 temporary). The most important lakes include Los Padres (in the Tandil Mountains). The compound lake system Salada Grande (approximately 1,350 km2 in size [Gral. Madariaga and Gral. Lavalle]) is composed of at least eight lakes, the largest being the laguna Salada Grande (6,078 ha). One unique environment is Mar Chiquita lagoon.

108. Southwest Pampas Basins--include the lotic environments of the northeast slope of the Sierra de la Ventana and the centripetal drainage area of Chasicó. The watercourses of the northeast slope of the mountain range are divergent, growing smaller due to evaporation and filtration into the plains of the "interserrana" pampa, where they disperse radially. The centripetal drainage area of Chasicó contains southern and southwestern streams that flow down from the mountains and end in the hypersaline area of Chasicó. There are 61 lakes (37 temporary). The compound lake system, called Lagunas Encadenadas del Oeste, encompasses about 58,000 ha.

V. SOUTHERN CONE

Patagonia Complex
This complex extends from the northern watershed of the Desaguadero-Salado and Colorado rivers to the Magallanes Channel in the south, as well as the Tierra del Fuego insular region. The Andes to the west form the ecoregion boundary with the Mediterranean and southern regions of Chile. Approximately 60 percent of the complex flows toward the Atlantic, 38 percent flows to the Pacific, and the remainder is comprised of closed basins.

Predominant westerly winds generate a gradient precipitation of 2,000-4,000 mm in the headwaters to 800-1,600 mm at lower elevations, with some latitudinal variation. Mid-elevation habitats along the eastern slopes of the Andes are particularly wet. The biota of this zone has significant endemism, with 34 percent in vascular plants, 23 percent in reptiles, 76 percent in amphibians, 33 percent in mammals, and 50 percent in fish. These wet environments are highly isolated from other similar regions in South America. The Patagonian region is much drier, with 80-150 mm annual precipitation. The xeric region extends from the south of the Mendoza Province to the north sector of Tierra del Fuego.

The Andes are the headwaters of numerous rivers and lakes. This area has nine protected areas of national jurisdiction, and several provincial and municipal protected areas. Intensive grazing has contributed to the desertification of over 30 percent of the Patagonian region, one of the principal threats to freshwater biodiversity. Dam-building, deforestation of headwaters, and introduced species are also major threats.

109. Río Colorado--comprises several basins, including those of the Desaguadero, Salado, Curacó, Chadileuvú, and Colorado rivers. Headwaters are in the Andes. There are also saline lakes, shallow lakes, and other wetlands. Llancanelo Lagoon is an important closed-basin lagoon. Two dams fragment these watersheds: Nihuil Dam on the Atuel River in the watershed of Salado and Casa de Piedra in the Colorado River. Oil contamination in the Colorado River has affected biodiversity and agriculture in the region.

110. Río Limay-Neuquen-Río Negro--most of this ecoregion drains into the Atlantic through the Río Negro. Lacar Lake and the Hua Hum River drain toward the Pacific. Much of the headwaters of the Limay River are protected by Lanin and Nahuel Huapi national parks. Here there exist many lakes of glacial origin surrounded by Nothofagus forests. Fauna that utilize these habitats include birds species (e.g., Anas specularis), amphibians (e.g., Athelognathus nitoi [limited to one lagoon of Chalhuaco Valley] and Rhinoderma darwini), mammals (e.g., Huillín, Lutra provocax), and many fish species (e.g., Galaxias platei, G. maculatus, Aplochiton taeniatus, and A. zebra).

The Laguna Blanca National Park, one of the most important in this region, is an important nesting site for many aquatic birds (e.g., Cygnus melanocorypha, Phoenicopterus chilensis, Atelognathus patagonicus, and A. praebasalticus), as well as ducks and shorebirds. Significant threats include hydroelectric dams, which are built on the Limay River and Neuquén; extensive urbanization causing contamination in some head-waters; impacts of tourism; and destruction of vegetation due to overgrazing.

111. Meseta Somuncura--includes closed-basin lagunas (shallow lakes), saline lakes, and intermittent wetlands and streams, some of which are hotsprings. Fish species include Gymnocaracinus bergi (located in hotsprings), and amphibians include Somuncuria somuncurensis and Atelognathus reverberii. Lagunas Carilaquen Grande and Chica, two important saline lakes, are important for the feeding and nursing of migratory shorebirds and ducks. Principal threats are overgrazing, desertification, and the introduction of exotic fish species.

112. Río Chubut-Río Chico--includes the mountainous chain of small watersheds of the Pacific: 1) Manso and Puelo, 2) Futaleufú, 3) Engaño and Pico, and 4) Simpson. At the south of the Chubut River, a closed-basin watershed is located on the Canquel Plateau, and toward the east, in the San Jorge Gulf and the Comodoro Rivadavia City, there is a watershed (Gran Bajo Oriental). Montane lakes occur in the national parks of Lago Puelo and Los Alerces, where one can find the recently discovered Batrachyla fitzroya in the Isla Grande of Menendez Lake. The lakes and streams

are home to many native fishes, such as Aplochiton zebra, Percichthys trucha, and Diplomystes viedmensis. Threats include heavy tourist impacts, overgrazing, and dams.

113. Río Deseado-Pacific--flowing watershed, corresponding to lakes Pueyrredón, Buenos Aires, and Posadas. Includes several closed-basin lakes at the Grant Antiplanicie Central alternate with saline lakes and wetlands. The estuary of the Deseado River supports important concentrations of shorebirds, including Phalacrocorax gaimardii, and several ducks in the genus Tachyeres and Lophonetta speculariodes. The Deseado River watershed is experiencing intense desertification.

114. Río Santa Cruz-Río Chico--formed from two watersheds: 1) Pacific drainage that encompasses Belgrano Lake, Mayer River, San Martín Lake, and the lakes and lagoons protected by the National Park of Perito Moreno (Roble Lagoon, Nansen Lakes, Azara, Belgrano and Volcán) and 2) river systems of Santa Cruz and Chico River. The first one starts in the lagos Argentino and Viedma, adjacent to Upsala and Perito Moreno glaciers. These lakes are located at the National Park Los Glaciares, which was declared a World Heritage Site in 1981. The Río Chico watershed receives waters from the lakes and lagoons situated at the north of the glacial area (lakes Strobel, Quiroga, and Burmeister). A closed-basin watershed is found around Lake Cardiel and at the west of the Cascajos Plateau. Many aquatic bird species have their southern limit here, including Agelaius thilius, Cistothorus platensis, and Tachuris rubrigastra. Many freshwater lagoons, brine, and saline lakes of the Strobel Plateau zone are important sites for Podiceps gallardoi, an endemic grebe of this region. Many ducks, swans, and flamingos inhabit these lagoons. Main threats are erosion of the lagoon beaches caused by overgrazing of sheep.

115. Río Coyle--includes lagoons, streams, and freshwater and brackish wetlands. Many aquatic bird species occur here, such as Podiceps gallardoi (found in the Escarchados Lagoon), an endemic grebe. Threats include destruction of vegetation through desertification, erosion of lagoons and beaches, and increase of sediment in rivers and streams, which can affect vegetation and aquatic fauna, thereby degrading conditions for reproduction for many species. Other threats include mining and oil exploitation. 116. Río Gallegos-headwaters arise in Nothofagus (Southern Beech) forests. Marshy regions occur at lower elevations. River outlet forms a 30-km long estuary.

117. Tierra del Fuego-Río Grande--includes two important watersheds on the island, one draining to the Pacific and containing Fagnano Lake and the other draining to the Atlantic. Fagnano Lake is protected by the National Park of Tierra del Fuego, which extends to the Beagle Channel at Lapataia Bay. Humid areas in the park support many acidic bogs.

APPENDIX D

Table D. Biological Distinctiveness Analysis: Criteria and Values

APPENDIX D

	Biological Distinctiveness Indicators				Special Considerations		
Ecoregion	Species Richness (2-10)	Endemism (3-15)	Ecosystem Diversity (1-5)	Total of Indicator Numbers (6-30)	Rarity of Major Habitat Type	Unusual Ecological/ Evolutionary Phenomena	Biological Distinctiveness
Baja California Complex							
1. Baja California	2	6	3	11			LI
Colorado River Complex							
2. Colorado Delta	2	6	2	10	RO[1]	RO[2]	RO
3. Sonoran	2	6	2	10			LI
Sinaloan Coastal Complex							
4. Sinaloan Coastal	4	9	3	16			RI
Rio Bravo Complex							
5. Rio Bravo	10	12	5	27			GO
6. Pecos	8	6	4	18			RO
7. Guzman	6	6	4	16			RI
8. Mapimi	4	9	3	16			RI
9. Cuatro Cienegas	10	15	5	30		GO[3]	GO

10. Llanos El Salado	2	15	5	22			RO
11. Conchos	6	9	4	19			RO
12. Lower Rio Bravo	8	12	4	24			RO
13. Rio San Juan	6	9	4	19			RO
14. Rio Salado	6	9	2	17			RI
Lerma/Santiago Complex							
15. Santiago	4	6	3	13			RI
16. Chapala	8	15	5	28	RO[4]	RO[5]	GO
17. Lerma	6	9	3	18			RO
18. Rio Verde Headwaters	2	15	1	18			RO
19. Manantlan/Ameca	4	9	4	17			RI
Rio Panuco Complex							
20. Rio Panuco	6	12	4	22			RO
Balsas Complex							
21. Balsas	2	12	3	17			RI
Pacific Central Complex							
22. Tehuantepec	4	9	3	16			RI
Atlantic Central Complex							
23. Southern Veracruz	6	12	3	21			RO
24. Belizean Lowlands	6	9	3	18			RO
25. Central American Caribbean Lowlands	6	9	3	18			RO
26. Talamancan Highlands	2	3	3	8			LI
27. Catemaco	6	12	4	22			RO
28. Coatzacoalcos	6	9	3	18			RO
29. Grijalva-Usumacinta	8	12	3	23			RO
30. Yucatan	4	9	5	18			RO

Scoring for biological distinctiveness indicators: higher numbers correspond to greater distinctiveness

Biological distinctiveness:

Globally Outstanding GO = 26-30
Regionally Outstanding RO = 18-25
Regionally Important RI = 13-17
Locally Important LI = 6-12
total range = 6-30 points

Special considerations: Assigning special considerations to an ecoregion automatically elevates its biological distinctiveness to the highest ranking received, regardless of total point score.

Rarity of major habitat types and unusual ecological/evolutionary phenomena:

[1] Large river delta
[2] Large-scale fish migrations
[3] Very high beta diversity/unusual adaptations and radiations
[4] Large tropical lakes
[5] Pronounced radiations of fish in tropical lakes
[6] Tropical saline lakes
[7] Extensive flooded savanna
[8] Large river channels

Table D Continued

Ecoregion	Biological Distinctiveness Indicators: Species Richness (2-10)		Ecosystem Diversity (1-5)	Total of Indicator Numbers (6-30)	Special Considerations: Rarity of Major Habitat Type	Unusual Ecological/ Evolutionary Phenomena	Biological Distinctiveness
31. Guatemalan Highlands	6	6	3	15	RO[4]		RO
32. Central American Karst Highlands	6	9	4	19			RO
33. Honduran/Nicaraguan Highlands	6	6	3	15			RI
34. Lake Nicaragua	8	9	4	21	RO[4]		RO
Isthmus Atlantic Complex							
35. Isthmus Atlantic	6	6	2	14			RI
Isthmus Pacific Complex							
36. Isthmus Pacific	6	9	2	17			RI
Bahama Archipelago Complex							
37. Bahamas	4	9	3	16			RI
Western Insular Caribbean Complex							
38. Cuba	8	12	3	23			RO
39. Hispaniola	6	12	3	21			RO
40. Jamaica	4	6	3	13			RI
41. Cayman Islands	2	6	3	11			LI

42. Florida Keys	2	3	3	8			LI
Eastern Insular Caribbean Complex							
43. Puerto Rico and Virgin Islands	8	12	3	23			RO
44. Windward & Leeward Islands	4	3	2	9			LI
Choco Complex							
45. Choco	10	12	2	24			RO
South American Caribbean Complex							
46. Magdalena	8	3	1	12			LI
47. Momposina Depression-Rio Cesar	8	3	2	13			RI
48. Cienega Grande de Santa Marta	8	3	3	14			RI
49. Guajira Desert	8	3	2	13			RI
50. Maracaibo Basin	8	12	2	22			RO
High Andean Complex							
51. Paramos	8	12	3	23			RO
52. Peru High Andean Complex	8	6	2	16			RI
53. Bolivian High Andean Complex	4	3	2	9			LI
54. Arid Puna	6	9	5	20	RO[6]		RO
55. Subandean Pampas	6	9	3	18			RO
56. South Andean Yungas	6	9	3	18			RO
Inter-Andean Dry Valleys Complex							
57. Inter-Andean Dry Valleys	4	3	1	8			LI
North Andean Montane Complex							
58. North Andean Montane	6	9	1	16			RI
59. Humid Andean Yungas	4	9	2	15			RI
60. Chuquisaca and Tarija Yungas	4	6	1	11			LI

Scoring for biological distinctiveness indicators: higher numbers correspond to greater distinctiveness

Biological distinctiveness:

Globally Outstanding GO = 26-30
Regionally Outstanding RO = 18-25
Regionally Important RI = 13-17
Locally Important LI = 6-12
total range = 6-30 points

Special considerations: Assigning special considerations to an ecoregion automatically elevates its biological distinctiveness to the highest ranking received, regardless of total point score.

Rarity of major habitat types and unusual ecological/evolutionary phenomena:

[1] Large river delta
[2] Large-scale fish migrations
[3] Very high beta diversity/unusual adaptations and radiations
[4] Large tropical lakes
[5] Pronounced radiations of fish in tropical lakes
[6] Tropical saline lakes
[7] Extensive flooded savanna
[8] Large river channels

Table D Continued

Ecoregion	Biological Distinctiveness Indicators: Species Richness (2-10)		Ecosystem Diversity (1-5)	Total of Indicator Numbers (6-30)	Special Considerations: Rarity of Major Habitat Type	Unusual Ecological/ Evolutionary Phenomena	Biological Distinctiveness
61. Salta and Tucuman Yungas	4	3	1	8			LI
62. Sierra de Cordoba	4	3	1	8			LI
Puyango-Tumbes Complex							
63. Puyango-Tumbes	10	9	2	21			RO
64. Atacama/Sechura Deserts	2	6	1	9			LI
Pacific Coastal Desert Complex							
65. Pacific Coastal Deserts	6	6	3	15			RI
Lake Titicaca/Poopo Complex							
66. Lake Titicaca	8	15	5	28	GO[4]	GO[5]	GO
67. Lake Poopo	6	6	5	17			RI
Galapagos Complex							
68. Galapagos	2	9	1	12			LI
Mediterranean Chile Complex							
69. North Mediterranean Chile	6	9	4	19			RO
70. South Mediterranean Chile	4	12	4	20			RO
Juan Fernandez Islands Complex							
71. Juan Fernandez Islands	4	9	4	17			RI

Southern Chile Complex							
72. Valdivian	6	9	5	20			RO
73. Chiloe Island	6	9	4	19			RO
74. Chonos Archipelago	4	6	4	14			RI
75. Magallanes/Ultima Esperanza	4	6	4	14			RI
Subantarctic Complex							
76. Subantarctic	2	3	4	9			LI
Venezuelan Coast/Trinidad Complex							
77. Venezuelan Coast/Trinidad	4	3	1	8			LI
Llanos Complex							
78. Llanos	10	12	5	27	RO[7]	GO[3]	GO
Guiana/Orinoco Complex							
79. Eastern Morichal	6	9	5	20			RO
80. Orinoco Delta	10	6	4	20	RO[1]		RO
81. Southern Orinoco	10	15	5	30	GO[8]		GO
82. Guiana Watershed	8	15	4	27			GO
Amazon Complex							
83. Amazon Delta	8	6	5	19	RO[1]		RO
84. Amazon Main Channel	10	9	5	24	GO[8]	GO[2]	GO
85. Northern Amazon Shield Tributaries	6	12	4	22			RO
86. Rio Negro	8	15	5	28		GO[2]	GO
87. Upper Amazon Piedmont	10	12	4	26			GO
88. Western Amazon Lowlands	8	9	3	20			RO

Scoring for biological distinctiveness indicators: higher numbers correspond to greater distinctiveness

Biological distinctiveness:

Globally Outstanding GO = 26-30
Regionally Outstanding RO = 18-25
Regionally Important RI = 13-17
Locally Important LI = 6-12
total range = 6-30 points

Special considerations: Assigning special considerations to an ecoregion automatically elevates its biological distinctiveness to the highest ranking received, regardless of total point score.

Rarity of major habitat types and unusual ecological/evolutionary phenomena:

1 Large river delta
2 Large-scale fish migrations
3 Very high beta diversity/unusual adaptations and radiations
4 Large tropical lakes
5 Pronounced radiations of fish in tropical lakes
6 Tropical saline lakes
7 Extensive flooded savanna
8 Large river channels

Table D Continued

Ecoregion	Biological Distinctiveness Indicators: Species Richness (2-10)		Ecosystem Diversity (1-5)	Total of Indicator Numbers (6-30)	Special Considerations: Rarity of Major Habitat Type	Unusual Ecological/ Evolutionary Phenomena	Biological Distinctiveness
89. Central Brazilian Shield Tributaries	8	9	3	20			RO
90. Tocantins-Araguaia	8	12	3	23			RO
Northeast Atlantic Complex							
91. Maranhao	6	3	3	12			LI
92. Northeast Mata-Atlantica	6	12	3	21			RO
93. East Mata-Atlantica	8	12	3	23			RO
94. Southeast Mata-Atlantica	8	12	3	23			RO
Sao Francisco Complex							
95. Caatinga	6	12	4	22			RO
96. Cerrado	6	12	4	22			RO
Upper Parana Complex							
97. Upper Parana	8	12	2	22			RO
Beni Complex							
98. Beni	8	6	3	17			RI
Paraguay-Parana Complex							
99. Pantanal	8	6	4	18		GO[7]	GO
100. Lower Parana	8	12	3	23			RI
Southern Atlantic Complex							
101. Jacui Highlands	4	3	3	10			LI
102. Lagoa dos Patos Coastal Plain	4	3	3	10			LI

Chaco Complex							
103. Chaco	6	6	5	17			RI
Pampas Complex							
104. Parano-Platense Basin	7	3	3	13			RI
105. Rio Salado and Arroyo Vallimanca Basin	5	3	5	13			RI
106. Northwest Pampas Basins	2	3	5	10			LI
107. Pampas Coastal Plains	4	3	5	12			LI
108. Southwest Pampas Basins	4	3	3	10			LI
Patagonia Complex							
109. Rio Colorado	6	6	3	15			RI
110. Rio Limay-Neuquen-Rio Negro	6	15	4	25			RO
111. Meseta Somuncura	4	15	3	22			RO
112. Rio Chubut-Rio Chico	6	12	3	21			RO
113. Rio Deseado	2	6	2	10			LI
114. Rio Santa Cruz-Rio Chico	2	6	3	11			LI
115. Rio Coyle	2	15	2	19			RO
116. Rio Gallegos	2	6	2	10			LI
117. Tierra del Fuego-Rio Grande	2	12	2	16			RI

Scoring for biological distinctiveness indicators: higher numbers correspond to greater distinctiveness

Biological distinctiveness:

Globally Outstanding GO = 26-30
Regionally Outstanding RO = 18-25
Regionally Important RI = 13-17
Locally Important LI = 6-12
total range = 6-30 points

Special considerations: Assigning special considerations to an ecoregion automatically elevates its biological distinctiveness to the highest ranking received, regardless of total point score.

Rarity of major habitat types and unusual ecological/evolutionary phenomena:

[1] Large river delta
[2] Large-scale fish migrations
[3] Very high beta diversity/unusual adaptations and radiations
[4] Large tropical lakes
[5] Pronounced radiations of fish in tropical lakes
[6] Tropical saline lakes
[7] Extensive flooded savanna
[8] Large river channels

APPENDIX E

Table E. Conservation Status Analysis: Criteria and Values

APPENDIX E

Conservation Status Indicators

Ecoregion	Fragmentation	Habitat Loss	Water Quality	Hydrographic Integrity	Catchment Alteration	Total	Conservation Status*
Baja California Complex							
1. Baja California	2	2	2	2	3	11	V
Colorado River Complex							
2. Colorado Delta	3	3	3	3	3	15	C
3. Sonoran	3	3	3	3	2	14	E
Sinaloan Coastal Complex							
4. Sinaloan Coastal	3	3	3	3	3	15	C
Rio Bravo Complex							
5. Rio Bravo	3	3	1	3	3	13	E
6. Pecos	3	3	3	3	2	14	E
7. Guzman	3	3	1	2	3	12	E
8. Mapimi	3	3	3	2	3	14	E
9. Cuatro Cienegas	2	2	3	2	2	11	V
10. Llanos El Salado	1	3	3	3	3	13	E
11. Conchos	3	2	3	3	3	14	E
12. Lower Rio Bravo	3	2	3	3	3	14	E
13. Rio San Juan	2	3	3	3	3	14	E
14. Rio Salado	3	3	3	2	3	14	E
Lerma/Santiago Complex							

15. Santiago	3	2	3	3	3	14	E
16. Chapala	1	2	3	3	3	12	E
17. Lerma	3	3	3	3	3	15	C
18. Rio Verde Headwaters	3	3	3	2	3	14	E
19. Manantlan/Ameca	2	2	1	1	2	8	V
Rio Panuco Complex							
20. Rio Panuco	3	3	3	2	3	14	E
Balsas Complex							
21. Balsas	3	2	3	3	3	14	E
Pacific Central Complex							
22. Tehuantepec	3	3	2	2	2	12	E
Atlantic Central Complex							
23. Southern Veracruz	3	3	2	2	2	12	E
24. Belizean Lowlands	2	2	1	2	2	9	V
25. Central American Caribbean Lowlands	2	2	1	1	1	7	RS
26. Talamancan Highlands	2	1	3	1	1	8	V
27. Catemaco	1	1	2	1	3	8	V
28. Coatzacoalcos	2	3	1	3	3	12	E
29. Grijalva-Usumacinta	2	2	1	2	2	9	V
30. Yucatan	2	2	3	1	2	10	V
31. Guatemalan Highlands	2	3	3	1	1	10	V

Scoring for conservation status indicators (loss or degradation): 3 = High
2 = Medium
1 = Low

*Critical (C) = 15
Endangered (E) = 12-14
Vulnerable (V) = 8-11
Relatively stable (RS) = 6-7
Relatively Intact (RI) = 5
total range = 5-15

Table E. (Continued)

	Conservation Status Indicators						
Ecoregion	Fragmentation	Habitat Loss	Water Quality	Hydrographic Integrity	Catchment Alteration	Total	Conservation Status*
32. Central American Karst Highlands	2	2	3	1	2	10	V
33. Honduran/Nicaraguan Highlands	2	2	3	2	3	12	E
34. Lake Nicaragua	3	3	1	2	3	12	E
Isthmus Atlantic Complex							
35. Isthmus Pacific	1	2	2	1	1	7	RS
Isthmus Pacific Complex							
36. Isthmus Pacific	3	3	2	2	2	12	E
Bahama Archipelago Complex							
37. Bahamas	1	1	2	1	1	6	RS
Western Insular Caribbean Complex							
38. Cuba	2	2	1	2	2	9	V
39. Hispaniola	3	3	2	3	3	14	E
40. Jamaica	3	3	2	3	3	14	E
41. Cayman Islands	1	2	1	3	2	9	V
42. Florida Keys	3	3	2	1	3	12	E
Eastern Insular Caribbean Complex							
43. Puerto Rico and Virgin Islands	2	2	2	2	3	11	V
44. Windward and Leeward Islands	3	2	3	2	2	12	E
Choco Complex							
45. Choco	2	2	2	2	2	10	V
South American Caribbean Complex							
46. Magdalena	3	3	3	3	3	15	C
47. Momposina Depression-Rio Cesar	1	1	3	1	1	7	RS
48. Cienega Grande de Santa Marta	1	3	3	3	3	13	E

49. Guajira Desert	1	3	1	2	3	10	V
50. Maracaibo Basin	3	3	3	3	3	15	C
High Andean Complex							
51. Paramos	1	1	1	2	2	7	RS
52. Peru High Andean Complex	1	1	2	3	3	10	V
53. Bolivian High Andean Complex	1	2	3	3	2	11	V
54. Arid Puna	2	2	2	2	3	11	V
55. Subandean Pampas	2	2	2	2	2	10	V
56. South Andean Yungas	2	2	2	2	3	11	V
Inter-Andean Dry Valleys Complex							
57. Inter-Andean Dry Valleys	2	1	3	2	2	10	V
North Andean Montane Complex							
58. North Andean Montane	3	2	3	2	2	12	E
59. Humid Andean Yungas	2	3	1	1	2	9	V
60. Chuquisaca and Tarija Yungas	3	2	3	2	2	12	E
61. Salta and Tucuman Yungas	2	2	2	2	3	11	V
62. Sierra de Cordoba	2	2	2	2	2	10	V

Scoring for conservation status indicators (loss or degradation): 3 = High
2 = Medium
1 = Low

*Critical (C) = 15
Endangered (E) = 12-14
Vulnerable (V) = 8-11
Relatively stable (RS) = 6-7
Relatively Intact (RI) = 5
total range = 5-15

Table E. (Continued)

Conservation Status Indicators

Ecoregion	Fragmentation	Habitat Loss	Water Quality	Hydrographic Integrity	Catchment Alteration	Total	Conservation Status*
Puyango-Tumbes Complex							
63. Puyango-Tumbes	2	2	2	2	3	11	V
Atacama/Sechura Complex							
64. Atacama/Sechura Deserts	3	3	3	3	3	15	C
Pacific Coastal Desert Complex							
65. Pacific Coastal Deserts	3	3	2	3	3	14	E
Lake Titicaca/Poopo Complex							
66. Lake Titicaca	2	1	2	2	3	10	V
67. Lake Poopo	3	3	3	3	3	15	C
Galapagos Complex							
68. Galapagos	1	1	2	1	1	6	RS
Mediterranean Chile Complex							
69. North Mediterranean Chile	3	3	3	3	3	15	C
70. South Mediterranean Chile	3	3	2	3	3	14	E
Juan Fernandez Islands Complex							
71. Juan Fernandez Islands	3	3	1	2	3	12	E
Southern Chile Complex							
72. Valdivian	2	2	2	2	3	11	V
73. Chiloe Island	3	3	2	1	3	12	E
74. Chonos Archipelago	2	2	1	1	1	7	RS
75. Magallanes/Ultima Esperanza	1	1	1	1	1	5	RI
Subantarctic Complex							
76. Subantarctic	1	1	1	1	1	5	RI
Venezuelan Coast/Trinidad Complex							
77. Venezuelan Coast/Trinidad	3	3	2	2	3	13	E
Llanos Complex							
78. Llanos	2	2	2	2	3	11	V
Guiana/Orinoco Complex							
79. Eastern Morichal	1	1	1	1	2	6	RS
80. Orinoco Delta	1	1	2	2	1	7	RS
81. Southern Orinoco	2	1	2	2	1	8	V

82. Guiana Watershed	1	1	2	1	1	6	RS
Amazon Complex							
83. Amazon Delta	1	1	1	1	2	6	RS
84. Amazon Main Channel	2	3	1	1	1	8	V
85. Northern Amazon Shield Tributaries	2	1	2	1	1	7	RS
86. Rio Negro	2	2	1	1	2	8	V
87. Upper Amazon Piedmont	1	2	2	1	2	8	V
88. Western Amazon Lowlands	1	1	1	1	1	5	RI
89. Central Brazilian Shield Tributaries	2	2	2	1	2	9	V
90. Tocantins-Araguaia	3	2	1	2	2	10	V

Scoring for conservation status indicators (loss or degradation): 3 = High
2 = Medium
1 = Low

*Critical (C) = 15
Endangered (E) = 12-14
Vulnerable (V) = 8-11
Relatively stable (RS) = 6-7
Relatively Intact (RI) = 5
total range = 5-15

Table E Continued

Conservation Status Indicators

Ecoregion	Fragmentation	Habitat Loss	Water Quality	Hydrographic Integrity	Catchment Alteration	Total	Conservation Status*
Northeast Atlantic Complex							
91. Maranhao	3	3	2	3	3	14	E
Mata-Atlantica Complex							
92. Northeast Mata-Atlantica	3	3	2	3	3	14	E
93. East Mata-Atlantica	3	3	2	3	3	14	E
94. Southeast Mata-Atlantica	3	3	2	3	2	13	E
Sao Francisco Complex							
95. Caatinga	3	2	2	2	3	12	E
96. Cerrado	3	2	2	2	3	12	E
Upper Parana Complex							
97. Upper Parana	3	3	2	3	2	13	E
Beni Complex							
98. Beni	2	2	1	2	1	8	V
Paraguay-Parana Complex							
99. Pantanal	2	1	2	3	2	10	V
100. Lower Parana	3	3	2	2	3	13	E
Southern Atlantic Complex							
101. Jacui Highlands	3	3	1	3	3	13	E
102. Lagoa dos Patos Coastal Plain	2	3	2	2	3	12	E
Chaco Complex							
103. Chaco	2	1	2	1	2	8	V
Pampas Complex							
104. Parano-Platense Basin	3	3	3	3	3	15	C
105. Rio Salado & Arroyo/Vallimanca Basin	2	1	3	3	2	11	V
106. Northwest Pampas Basins	2	1	2	3	2	10	V
107. Pampas Coastal Plains	2	1	2	3	2	10	V
108. Southwest Pampas Basins	2	1	2	2	1	8	V
Patagonia Complex							
109. Rio Colorado	3	2	2	1	1	9	V
110. Rio Limay-Neuquen-Rio Negro	3	2	2	2	1	10	V
111. Meseta Somuncura	2	2	2	2	1	9	V
112. Rio Chubut-Rio Chico	2	2	2	1	1	8	V
113. Rio Deseado	2	2	2	1	2	9	V
114. Rio Santa Cruz-Rio Chico	2	2	2	1	1	8	V
115. Rio Coyle	2	2	2	1	1	8	V
116. Rio Gallegos	2	2	2	1	1	8	V
117. Tierra del Fuego-Rio Grande	2	1	1	1	1	6	RS

Scoring for conservation status indicators (loss or degradation):	3 = High 2 = Medium 1 = Low	*Critical (C) = 15 Endangered (E) = 12-14 Vulnerable (V) = 8-11 Relatively stable (RS) = 6-7 Relatively Intact (RI) = 5 total range = 5-15

APPENDIX F--GLOSSARY

adaptive radiation--The evolution of a single species into many species that occupy diverse ways of life within the same geographical range (Wilson 1992).

alpha-diversity--Species diversity within a single site.

amphibian--A member of the vertebrate class Amphibia (e.g., frogs and toads, salamanders, and caecilians).

anthropogenic--Human-induced change to nature or a natural system.

aquatic--Growing in, living in, or frequenting water.

arapaima--A primitive, large-scaled bony fish (Arapaima gigas) of the rivers of the Amazon region.

assemblage--In conservation biology, a predictable and particular collection of species within a biogeographic unit (e.g., ecoregion or habitat).

basin--See catchment.

beta-diversity--Species diversity between habitats (thus reflecting changes in species assemblages along environmental gradients).

biodiversity--The variety of organisms considered at all levels, from genetic variants belonging to the same species through arrays of species to arrays of genera; families, and still higher taxonomic levels; includes the variety of ecosystems that comprise both communities of organisms within particular habitats and the physical conditions under which they live. Also known as biotic or biological diversity (Wilson 1992).

biogeographic unit--A delineated area based on biogeographic parameters.

biogeography--The study of the geographic distribution of organisms, both past and present (Brown and Gibson 1983).

biological distinctiveness--Scale-dependent assessment of the biological importance of an ecoregion based on species richness, endemism, relative scarcity of ecoregion type, and rarity of ecological phenomena. Biological distinctiveness classes are "globally outstanding," "regionally outstanding," "regionally important," and "locally important."

biome--A global classification of natural communities in a particular region based on dominant or major vegetation types and the climate.

bioregion--A geographically related assemblage of ecoregions that share a similar biogeographic history and thus have strong affinities at higher taxonomic levels (e.g., genera, families).

biota--The combined flora, fauna, and microorganisms of a given region (Wilson 1992).

biotic--Biological, especially referring to the characteristics of faunas, floras, and ecosystems (Wilson 1992).

bog--A poorly drained area rich in plant residues, usually surrounded by an area of open water, and having characteristic flora.

catchment--All lands enclosed by a continuous hydrologic-surface drainage divide and lying upslope from a specified point on a stream (Maxwell et al. 1995); or, in the case of closed-basin systems, all lands draining to a lake.

characoid--Any of the numerous freshwater fishes in the diverse, neotropical family, Characidae, distinguished by toothed jaws and usually a second dorsal (adipose) fin on the back.

community--Collection of organisms of different species that co-occur in the same habitat or region and that interact through trophic and spatial relationships (Fielder and Jain 1992).

conservation biology--Relatively new discipline that treats the content of biodiversity, the natural processes that produce it, and the techniques used to sustain it in the face of human-caused environmental disturbance (Wilson 1992).

conservation status--Assessment of the status of ecological processes and of the viability of species populations in an ecoregion. The status categories used are "extinct," "critical," "endangered," "vulnerable," "relatively stable," and "relatively intact." The "snapshot" conservation status is based on an index derived from values of four landscape-level variables. The final conservation status is the snapshot assessment modified by an analysis of threats to the ecoregion over the next 20 years.

conversion--Habitat altered by human activities to such an extent that it no longer supports most characteristic native species and ecological processes.

critical--Conservation status characterized by low probability of persistence of remaining intact habitat.

cryptorheic--Term used to characterize basins with underground discharge.

degradation--Loss of native species and processes due to human activities such that only certain components of the original biodiversity still persist, often including significantly altered natural communities.

disturbance--Any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment (Fielder and Jain 1992).

drainage basin--See catchment.

drums--Any of a family (Sciaenidae) of marine and freshwater fishes that make a drumming sound.

ecological processes--Complex mix of interactions between animals, plants, and their environment that ensure an ecosystem's full range of biodiversity is adequately maintained. Examples include population and predator-prey dynamics, nutrient cycling, migration, and dispersal.

ecological service--Service provided free by an ecosystem or by the environment, such as clean air, clean water, and flood amelioration.

ecoregion--A large area of water or land that contains a geographically distinct assemblage of natural communities that (a) share a large majority of their species and ecological dynamics, (b) share similar environmental conditions, and (c) interact ecologically in ways that are critical for their long-term persistence.

ecosystem--System resulting from the integration of all living and nonliving factors of the environment (Tansley 1935).

endangered--Conservation status category characterized by medium to low probability of persistence of remaining intact habitat.

endemic--Species or race native to a particular place and found only there (Wilson 1992). endemism Degree to which a geographically circumscribed area, such as an ecoregion or a country, contains species not naturally occurring elsewhere.

endorheic--Referring to a closed basin with no natural watercourses leading to the sea.

environmental gradients--Changes in biophysical parameters, such as rainfall, elevation, or soil type over distance.

estuarine--Pertaining to a phenomenon associated with an estuary.

estuary--Deepwater tidal habitat and its adjacent tidal wet-lands, which are usually semi-enclosed by land but have open, partly obstructed, or sporadic access to the open ocean, and in which ocean water is at least occasionally diluted from fresh-water runoff from the land (Maxwell et al. 1995).

evolutionary phenomenon--Within the context of WWF regional conservation assessments, refers to patterns of community structure and taxonomic composition that result from extraordinary evolutionary processes, such as pronounced adaptive radiations.

evolutionary radiation--See radiation.

exotic species--Species not native to an area that has been introduced intentionally or unintentionally by humans; not all exotics become successfully established.

extinct--Term used to describe a species or population that has been lost.

extinction--Termination of any lineage of organisms, from subspecies to species and higher taxonomic categories, from genera to phyla. Extinction can be local, in which one or more populations of a species or other unit vanish but others survive elsewhere, or total (global), in which all populations vanish (Wilson 1992).

extirpated--Status of a species or population that has completely vanished from a given area but that continues to exist in some other location.

extirpation--Process by which an individual, population, or species is totally destroyed (Fielder and Jain 1992).

family--In the hierarchical classification of organisms, a group of species of common descent higher than the genus and lower than the order; a related group of genera (Wilson 1992).

fauna--All the animals found in a particular place.

flooded grassland--Grassland habitat that experiences regular inundation by water.

flora--All the plants found in a particular place.

fragmentation--1. Aqua/landscape-level variable measuring the degree to which remaining habitat is separated into smaller discrete blocks. 2. Process by which habitats are increasingly subdivided into smaller units (Fielder and Jain 1992).

freshwater--In the strictest sense, water that has less than 0.5% of salt concentration (Brown and Gibson 1983); in this study, refers to rivers, streams, creeks, springs, and lakes.

genera--Plural of genus.

genus--A group of similar species with common descent, ranked below the family (Wilson 1992).

globally outstanding--Biological distinctiveness class for units of biodiversity whose biodiversity features are equaled or surpassed in only a few other areas around the world.

guild--Group of organisms, not necessarily taxonomically related, that are ecologically similar in such characteristics as diet, behavior, or microhabitat preference, or with respect to their ecological role in general.

habitat--An environment of a particular kind (Wilson 1992).

habitat blocks--Aqua/landscape-level variable that assesses the number and extent of blocks of contiguous habitat, taking into account size requirements for populations and ecosystems to function naturally. It is measured here by a habitat-dependent and ecoregion size-dependent system.

habitat loss--Aqua/landscape-level variable that refers to the percentage of the original habitat area of the ecoregion that has been lost (converted). It underscores the rapid loss of species and disruption of ecological processes predicted to occur in ecosystems when the total area of remaining habitat declines.

habitat type--In this study, it is defined by the structure and processes associated with one or more natural communities. An ecoregion is classified under one major habitat type, but may encompass multiple habitat types.

headwater--The source of a stream or river.

herpetofauna--All species of amphibians and reptiles inhabiting a specified region.

hydrographic--Refers to study, description, and mapping of oceans, lakes, and rivers, especially with reference to their navigational and commercial uses.

igapó--Inundated communities occurring on nutrient-poor white sands of the Amazon and Orinoco basins.

inselbergs--Isolated outcroppings or ranges.

intact habitat--Relatively undisturbed areas characterized by the maintenance of most original ecological processes and by communities with most of their original native species still present.

introduced species--See exotic species.

invasive species--Exotic species (i.e., alien or introduced) that rapidly establishes itself and spreads throughout the natural communities to which it is introduced.

invertebrate--Any animal lacking a backbone or bony segment that encloses the central nerve cord (Wilson 1992).

karst--Term applied to areas underlain by gypsum, anhydrite, rock salt, dolomite, quartzite (in tropical moist areas), and limestone; often highly eroded, complex landscapes with high levels of plant endemism.

keystone species--Species critically important for maintaining ecological processes or the diversity of their ecosystems.

lacustrine--Living in lakes or ponds.

lagunas--Shallow lakes of the Southern Cone savannas and steppes. landscape ecology Branch of ecology concerned with the relationship between landscape-level features, patterns, and processes and the conservation and maintenance of ecological processes and biodiversity in entire ecosystems.

lentic--Refers to standing freshwater habitats, such as ponds and lakes (Brown and Gibson 1983).

life cycle--The entire lifespan of an organism from the moment it is conceived to the time it reproduces (Wilson 1992).

lotic--Refers to running freshwater habitats, such as springs and streams (Brown and Gibson 1983).

macro-invertebrates--Invertebrates large enough to be seen with the naked eye (e.g., most aquatic insects, snails, and amphipods) (Maxwell et al. 1995).

macrophyte--Large plant.

major habitat type--Set of ecoregions that (a) experience comparable climatic regimes, (b) have similar vegetation structure, (c) display similar spatial patterns of biodiversity, and (d) contain flora and fauna with similar guild structures and life histories. (Nine major habitat types are defined in this study.)

mire--A wetland where vegetation is rooted in deep peat.

mollusk--Animal belonging to the phylum Mollusca, such as a snail or clam (Wilson 1992).

morichales--Habitats supporting moriche palms.

natural disturbance event--Any natural event that significantly alters the structure, composition, or dynamics of a natural community (e.g., floods, fire, and storms).

natural range of variation--Characteristic intensity and periodicity associated with disturbances, population levels, or frequency of habitat or communities.

non-native species--See exotic species.

nonpoint source--Diffuse form of water quality degradation produced by erosion of land that causes sedimentation of streams, eutrophication from nutrients and pesticides used in agricultural and silvicultural practices, and acid rain resulting from burning fuels that contain sulfur.

oliogotrophic--Freshwater systems having low productivity.

palustrine--Refers to wet or marshy habitats.

páramo--Montane shrublands and wetlands of moist tropical mountains.

pirarucu--See arapaima.

population--In biology, any group of organisms belonging to the same species at the same time and place (Wilson 1992).

predator-prey system--Assemblage of predators and prey species and the ecological interactions and conditions that permit their long-term coexistence.

protection--Aqua/landscape-level variable that assesses how well humans have conserved large blocks of intact habitat and the biodiversity they contain. It is measured here by the number of protected blocks and their sizes in a habitat-dependent and ecoregion size-dependent system.

radiation--Diversification of a group of organisms into multiple species, due to intense isolating mechanisms or opportunities to exploit diverse resources.

rarity--Seldom occurring either in absolute number of individuals or in space (Fielder and Jain 1992). refugia Habitats that have allowed the persistence of species or communities because of the stability of favorable environmental conditions over time.

regionally important--Biological distinctiveness class.

regionally outstanding--Biological distinctiveness class.

relatively intact--Conservation status category indicating the least possible disruption of ecosystem processes. Natural communities are largely intact with species and ecosystem processes occurring within their natural ranges of variation.

relatively stable--Conservation status category between "vulnerable" and "relatively intact" in which extensive areas of intact habitat remain but in which local species have declined and disruptions of ecological processes have occurred.

relictual taxa--Species or group of organisms largely characteristic of a past environment or ancient biota.

reophilic--Organism specialized on running waters.

representation--Protection of the full range of biodiversity of a given biogeographic unit within a system of protected areas.

restoration--Management of a disturbed and/or degraded habitat that results in recovery of its original state (Wilson 1992).

riparian--Refers to the interface between freshwater streams and lakes and the terrestrial landscape.

salares--Alkaline or saline lakes or dry basins of the Southern Cone.

saline--Water with a significant salt content.

savanna--Habitat largely dominated by grasslands but with woodland and gallery forest elements.

semiaquatic--Living partly in or adjacent to water (Brown and Gibson 1983).

source pool--Habitat that provides individuals or propagules that disperse to and colonize adjacent or neighboring habitats.

species--Basic unit of classification, consisting of a population or series of populations of closely related and similar organisms (Wilson 1992).

species richness--Simple measure of species diversity calculated as the total number of species in a habitat or community (Fielder and Jain 1992).

spring--Natural discharge of water as leakage or overflow from an aquifer through a natural opening in the soil/rock onto the land surface or into a body of water.

stream--General term for a body of flowing water (Maxwell et al. 1995); often used to describe a mid-sized tributary (as opposed to a river or creek).

subspecies--Subdivision of a species; usually defined as a population or series of populations occupying a discrete range and differing genetically from other geographical races of the same species (Wilson 1992).

taxon (pl., taxa)--General term for any taxonomic category, e.g., a species, genus, family, or order (Brown and Gibson 1983).

teleost--Any of many orders of bony fishes having a consolidated internal skeleton, swim bladder, thin cycloid scales, etc.

tepuis--Isolated plateaus in northern South America with highly endemic biotas.

terrestrial--Living on land.

tributary--Stream or river that flows into a larger stream, river, or lake feeding it water.

umbrella species--Species whose effective conservation will benefit many other species and habitats, often due to their large area requirements or sensitivity to disturbance.

varzea--Seasonally inundated forests of the Amazon and Orinoco River basins.

vascular plant--Plant that possesses a specialized water-conducting tissue, called xylem, which is a stiff supporting tissue of nonliving cells, and has a food-conducting tissue called phloem.

vulnerable--Conservation status characterized by good probability of persistence of remaining intact habitat (assuming adequate protection) but also by loss of some sensitive or exploited species.

watershed--See catchment.

wetlands--Those areas inundated or saturated by surface or ground water at a frequency and duration sufficient to support (and under normal circumstances they do support) a prevalence of vegetation typically adapted for life in saturated soil conditions; lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water (Maxwell et al. 1995).

xeric--Dryland and desert areas.

APPENDIX G

Additional Souces on Freshwater Biodiversity

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